AD-A072 352 VERTEX CORP ROCKVILLE MD F/G 5/3

METHODOLOGY TO QUANTIFY THE POTENTIAL NET ECONOMIC CONSEQUENCES--ETC(U)

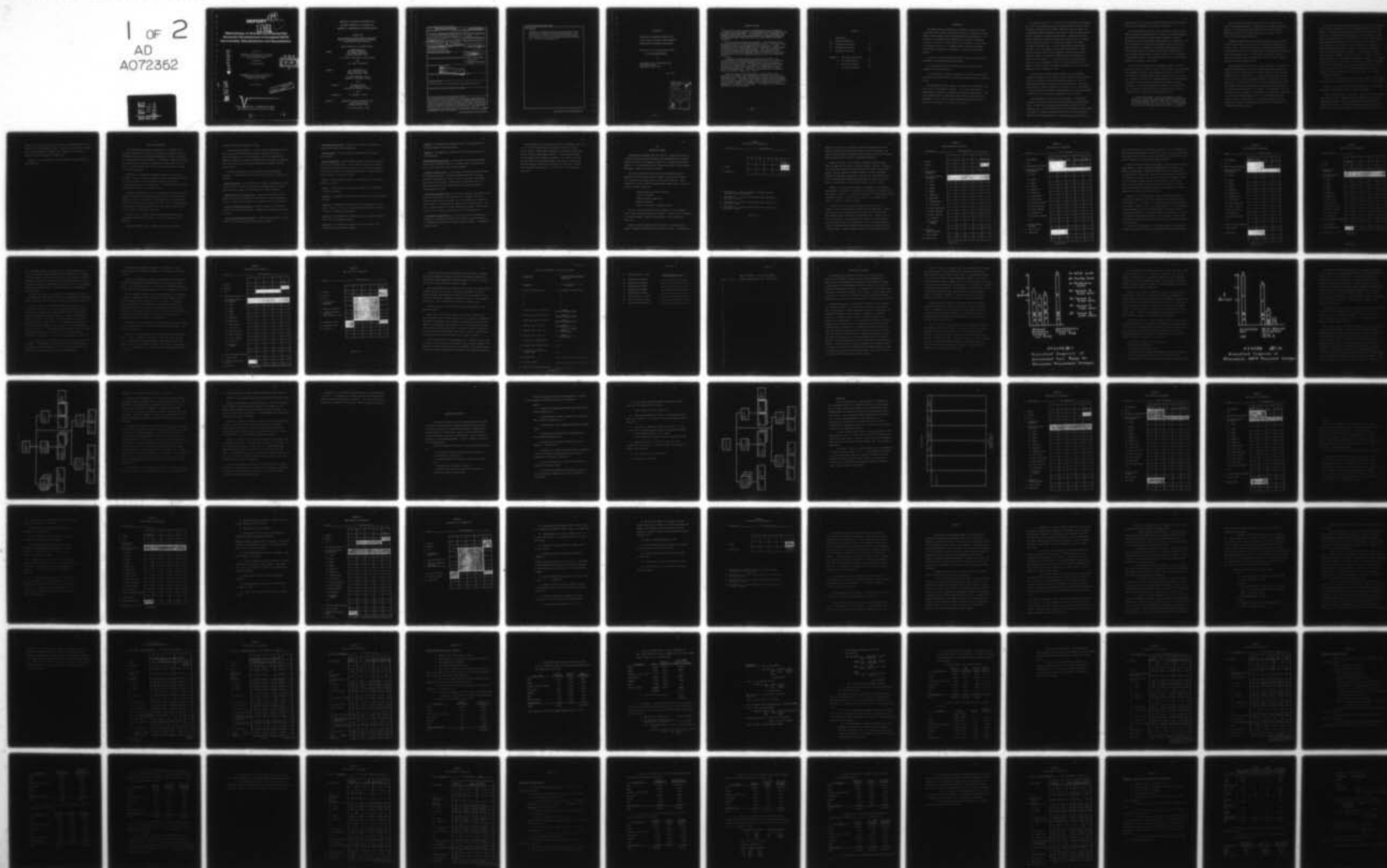
OCT 78 D GREENWOOD, B P KLOTZ, T A SMITH MDA903-78-C-0166

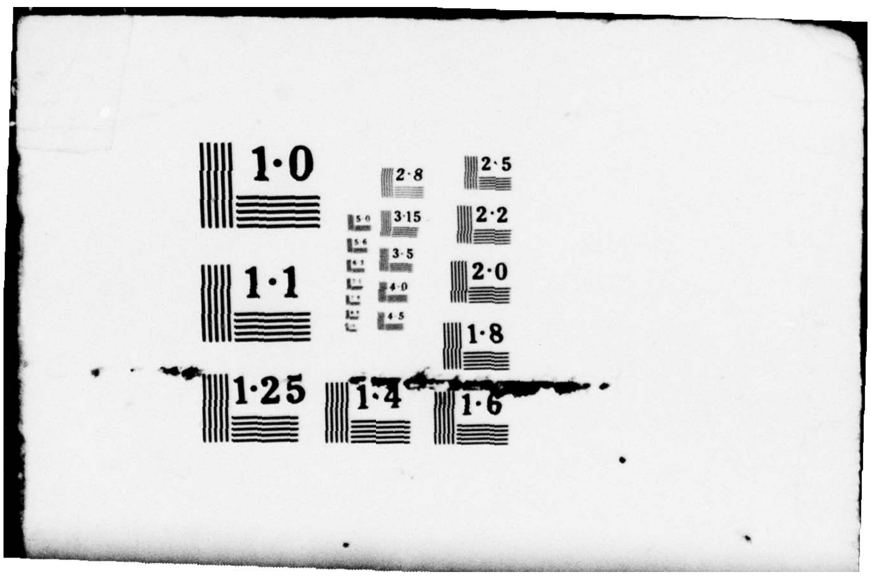
UNCLASSIFIED NL

1 OF 2

AD

A072352




1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6

19

REPORT

VOLUME III

LEVEL III

A072351

Methodology to Quantify the Potential Net Economic Consequences of Increased NATO Commonality, Standardization and Specialization

AD A072352

Prepared for:

The International Economic Affairs Directorate
Office of the Assistant Secretary of Defense
International Security Affairs

In response to:

MDA 903-78-C-0166

By:

MANAGEMENT ANALYSIS INCORPORATED
7910 Woodmont Avenue, Suite 1312
Bethesda, Maryland 20014

as

Sub-contractor to:

THE VERTEX CORPORATION
2401 Research Boulevard, Rockville Maryland 20850

METHODOLOGY TO QUANTIFY THE POTENTIAL NET ECONOMIC CONSEQUENCES OF INCREASED NATO COMMONALITY, STANDARDIZATION AND SPECIALIZATION

Prepared for:

The International Economic Affairs Directorate
Office of the Assistant Secretary of Defense
International Security Affairs

Major Contributors to Complete Report:

VOLUME I

Prime Contractor
THE VERTEX CORPORATION
2401 Research Boulevard
Rockville, Maryland 20850

Dr. William C. Pettijohn, Project Director

with

Dr. Jacob A. Stockfisch

VOLUME II

C & L ASSOCIATES, INC.
10871 Spring Knoll Drive
Potomac, Maryland 20854

Mr. David Greenwood, Author
University of Aberdeen, Scotland

with

Appendix I

Dr. Keith Hartley
NATO Research Fellow
University of Aberdeen, Scotland

and

Appendix II

Dr. Benjamin P. Klotz

VOLUME III

MANAGEMENT ANALYSIS INCORPORATED (MAI)
7910 Woodmont Avenue
Bethesda, Maryland 20014

Dr. T. Arthur Smith, Author

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER (6)

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER (9)

4. TITLE (and Subtitle) Methodology to Quantify the Potential Net Economic Consequences of Increased NATO Commonality, Standardization and Specialization. Volume III.

5. TYPE OF REPORT & PERIOD COVERED
FINAL rept.,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s) (10)
Mr. David GREENWOOD, ~~Dr.~~ Keith HARTLEY
Dr. Benjamin KLOTZ, Dr. William PETTIJOHN
Dr. T. Arthur SMITH, Dr. Jacob STOCKFISCH

8. CONTRACT OR GRANT NUMBER(s) (15)
MDA 903-78-C-0166

9. PERFORMING ORGANIZATION NAME AND ADDRESS
THE VERTEX CORPORATION
2401 Research Boulevard
Rockville, Maryland 20850

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
(12) 143p.

11. CONTROLLING OFFICE NAME AND ADDRESS

12. REPORT DATE (11)
13 Oct[redacted] 1978

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Economic Aanlysis, Cost Methodology, NATO Weapons Production

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study defines and demonstrates interrelated methodologies for estimating the costs of cooperative NATO weapons systems production programs for (a) individual programs (the MICRO methodology) and (b) NATO Alliance member nations (the MACRO methodology). The MICRO methodology is based on standard cost estimating techniques and requires detailed input data concerning production factors. The MACRO methodology relies on production data from analogous industrial (OVER)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

388 107

mit

(20) Abstract

activities in combination with gross expected major system acquisitions to estimate gross economies available to the Alliance from utilization of least cost production option. Cost estimates derived by both MICRO and MACRO methodologies are for demonstration purposes only.

REPORT

METHODOLOGY FOR MEASURING POTENTIAL COST SAVING THROUGH NATO WEAPON SYSTEM STANDARDIZATION AND/OR PROCUREMENT SPECIALIZATION

Submitted to the Vertex Corporation under
Contract MDA 903-78-C-0166

by

MANAGEMENT ANALYSIS INCORPORATED (MAI)
7910 Woodmont Avenue
Bethesda, Maryland 20014

July 1978

EXECUTIVE SUMMARY

This Technical Report describes a methodology for examining potential cost savings to the NATO Community through standardization and/or specialization in weapons systems procurement. The methodology is one of comparative cost analysis and specifically establishes procedures for comparing program costs for alternative weapon system buys under two or more competing procurement strategies.

Five procurement strategies are considered. Four alternatives were defined prior to contract start and selected by the COTR. The fifth, termed "National Initiative," was developed to provide a base case. Initial consideration of the problem posed showed that potential cost savings should be identified early in the development stage. This led to a decision to structure the methodology by major subsystems since conventional cost estimating techniques permit estimating based on performance characteristics, and these may be the only distinguishing features in the early development stage.

Information requirements based on subsystem identification, the characteristics of the procurement strategies and the need for consistency across alternatives to provide comparative costs led to a preliminary structuring of output formats. An examination of tank and aircraft costs displayed in the preliminary formats led to the identification of a basic set of building blocks, input procedures, and a revised set of formats. These form the methodology. Three weapon system areas were then examined. These are described in Appendices A, B, and C.

During the course of the investigation, it became apparent that fluctuations in exchange rates could substantially modify the results of a comparative cost analysis that included several NATO countries as developers and manufacturers. Development of procedures to handle fluctuating exchange rates is beyond the scope of the study; however, where cost data was available only in foreign currency, the information was recorded and the method of determining a U.S. dollar value described. In no instance are these methods presented as preferred techniques.

OUTLINE

I.

INTRODUCTION

This report describes a methodology for examining a weapon system area and developing cost estimates for potential savings to be achieved by the NATO community through weapon systems standardization and/or specialization. The methodology, as developed to date, considers cost in terms of alternative procurement strategies. The methodology could be extended to consider other cost categories such as R & D, replacement parts, and logistical support. At this stage of development the methodology is capable of serving three purposes:

a. As input to a macro-economic approach for examining the net economic consequences of alternative procurement decisions.

b. As a screening device for identifying candidate systems for NATO standardization and specialization.

c. As a generator of information requirements for in-depth investigations of potential cost savings inherent in specific procurement decisions on specific systems.

This methodology has been tailored to a specific set of information needs of the Office of the Secretary of Defense. It is not a generalized cost methodology for estimating the probable cost of specific weapon systems. This costing approach falls in with the more general family of comparative cost methologies. It is a utilizer of weapon system cost data and a provider of program cost ranges under a precise set of assumptions.

The underlying rationale is a concern for providing Defense policy-makers with a tool for discriminating among alternative procurement strategies where one Defense consideration is an economic improvement over the "normal" case of independent system development and acquisition by those NATO member nations having the capability to produce complex weaponry. Recognizing that there are many significant considerations other than economic choice in the weapon systems acquisition process, it is nevertheless suggested that Defense policymakers need such a tool, if only to enable them to evaluate general statements such as "Furthermore, this direction saves billions." Policy decisions are most effective when implemented in the early weapon system requisition process, a time when the number of feasible alternatives is generally at its greatest. It is suggested that any economic choice tool should not only be comparative in nature, but also constructed in such a manner as to permit the rapid development of comparisons at a level of detail appropriate to the information at hand.

If one assumes, all other things being equal, that the investment (research, development, and procurement) levels of NATO nations are relatively fixed, then investment decisions that reduce the average unit costs of a desirable weapon system are beneficial to NATO effectiveness. The results may be realized in terms of additional units fielded, or in the availability of investment funds for development and procurement of other desirable systems in addition to the initial quantity proposed for the first system.

This report makes one politico-economic assumption: industrialized countries are reluctant to degrade their technological and industrial bases and are inclined to sacrifice optimal weapon system investment solutions toward this end. The politico-economic solution then becomes the middle ground; an improved but non-optimal defense posture within the implied expenditure limits of today's budget projections. These projections may provide for an

annual increase in real terms for defense expenditures, with such increases fitting within the assumption of relatively fixed levels.

Within the context of the above, one can postulate an almost infinite range of alternative procurement options. However, a generalized approach may offer special insights into the potential advantages of national specialization within an environment of NATO member nation cooperation. The initial assumption of relatively fixed investment levels by NATO nations permits the anlyst to hypothesize a NATO defense budget extending over a multi-year period where the reduction of total NATO expenditures for a specific weapon system without a concurrent reduction in units fielded can be designated as savings. The methodology does not concern itself with the subsequent utilization of such savings.

We are therefore concerned with a measurement problem. That to be measured is savings in a specific category, NATO investment, through selection of a procurement strategy. This presupposes a base line with savings to be a reduction in investment costs from the costs identified for the base line. Selection of a base line is somewhat arbitrary for a specific weapon system since prior decisions may have established elements of partial cooperation. For the more generalized case, however, a satisfactory base line is a position of national initiative in weapon systems acquisition. In a formal sense, national initiative may be defined as:

> Given a NATO need for a weapon system capability, those nations with the necessary technological capability and industrial base develop, produce, and field systems that, in aggregate, meet the NATO requirements. Thus if the NATO need is for 5,000 fielded units, this total number of units will be fielded. The composition of the force will be several systems, each with its own sponsor.

Given a procurement strategy of national initiative, there will be, fron an overall NATO perspective, a redundance in R & D efforts and production facilities. The average recurring production cost will reflect multiple production facilities and will exceed such costs at a single, efficient facility where labor learning takes place.

A methodology designed to identify potential savings to the total NATO community from a national initiative base line needs several dimensions, one of which is time. If potential savings can be identified sufficiently early in the planning cycle, they can include research and development costs, facility costs, and production costs. At a later time, savings may be limited to facility and production costs, and later still the only available investment savings are recurring production costs.

This methodological requirement has several implications. Unless several estimating techniques are to be used, the methodological approach should be susceptible to cost interpretation at the DSARC O Milestone. This means that parametric results should be used. At this stage one can anticipate identification of alternative system, and perhaps subsystem, configurations for each alternative. A second implication is that the cost categories should be somewhat flexible to permit the utilization of available data rather than keyed to detailed engineering estimates. For example, it is legitimate to deal with investment costs as a category if the data base on a foreign weapon system does not provide the preferred breakout of R & D, non-recurring and recurring production costs. In this situation, one can make assumptions as to cost relationships between R & D and program that will permit some carefully constructed cost/quantity extensions.

There is a further methodology requirement for dealing with cost estimates where the system has undergone full scale development and may even be in production. The additional cost definition available should be utilized to the extent that it provides meaningful information to the policy maker. The data should also be compatible with cost information on less well defined systems. These methodological requirements and the underlying rationale have been brought together by the utilization of an interlocking set of formats. The output format, designated Format A, provides a display of total investment costs for alternative production strategies. It is supported by a set of formats where each identified procurement strategy has a display in greater detail than Format A. These formats are numbered B-1 through B-5. As additional procurement strategies are identified, the B family of formats can be extended. The B-1 Format, which displays the national initiative procurement strategy, is in turn supported by a set of cost displays designated as C-1. Each national initiative weapon system has its own C-1 display. These formats are described in Chapter III.

Chapter II of this report deals with terms and assumptions. These include the alternative procurement strategies used as a basis for this investigation.

Chapter IV is an excursion into possible utilization of this methodology and Chapter V describes the product in a step by step manner.

There are four appendices to this report. Appendices A through C display methodology utilization. Appendix A develops comparative costs for three competing tank systems. The costs are developed using statistical cost estimating relationships. This technique provides sub-system costs in the absence of a Military Service estimate. The cost estimating procedures are

documented in some detail to assist the sponsor in his understanding of what is possible with the methodological concept. Appendix B is an air defense scenario where costs are extended via learning curve. Appendix C is a tactical A analysis using the same approach as Appendix 13.

Appendix D is a development of data base requirements for exploitation of this methodology.

II.

TERMS AND ASSUMPTIONS

This chapter develops terms and assumptions for the comparative cost methodology prepared for the Office of the Secretary of Defense to assist in quantifying the potential net economic consequences of increased NATO commonality standardization and specialization. The sequence of ordering these terms and assumptions tends to follow the introduction of these terms into this report. This approach was taken in order to assist the reader in following the methodological concept.

- Methodology - A framework for examining a related set of problems or questions. The term is defined in Webster's Seventh New Collegiate Dictionary as a body of methods, rules and postulates employed by a discipline; a particular procedure or set of procedures. 2: The analysis of the principles or procedures of inquiry in a particular field.

- Comparative Cost Methodology - A set of procedures for examining the cost elements of alternatives that emphasizes consistency of entries and element composition across all alternatives. This approach tends to assume that the differences (deltas) between aggregated cost totals for the various alternatives are reasonable by treating each imprecision in cost element estimates in an identical fashion, alternative by alternative.

- Investment Costs - A general term for costs incurred during research, development and procurement of a system. This is an economic, not a DOD definition.

- Operating and support costs - A general term for costs incurred in

fielding, operating and maintaining a system.

- Politico-economic Assumption - A rationale based on observation or policy that a certain set of political and economic considerations will tend to dominate a problem area. In this methodology, there is an assumption that industrial countries are reluctant to degrade their technological and industrial bases and inclined to sacrifice optimal weapon system investment solutions toward this end.

- Procurement Strategies - Sets of procurement goals and generalized guidelines. In this methodology the following NATO procurement strategies are considered:

National Initiative - Given a NATO need for a weapon system capability, those nations having the necessary technological and industrial base will develop, produce and field systems that in aggregate meet the NATO requirement.

Common Production -- Sub-systems only - Single-country production of sub-systems whether for inter-changeable, inter-operable or jointly produced full systems. Assembly of full systems may be performed in one or more countries.

Parallel Multi-National Production - Parallel production of the same sub-systems in more than one NATO country. Assembly may be performed in more than one country.

Distributed Multi-National Production - Single-country production of all sub-systems of a NATO weapon system with multi-country assembly.

Specialization Production - Single-country production and assembly of a weapon system to meet the NATO requirement.

- NATO Requirement - The total number of weapon system units needed by NATO countries.

- National Requirement - The total number of weapon system units to be produced by a single NATO country. If, for example, the FRG were to produce a system for both German and Dutch services, the FRG National Requirement is the total to be produced. The National Requirements of all NATO producing members aggregate to the NATO Requirement.

- Format - A display framework used within the methodology. The following formats are utilized:

Format A - The framework for displaying cost comparisons of alternative Procurement Strategies.

Format B-1 - The framework for displaying the National Initiative Procurement Strategy.

Format C-1 - The framework for displaying National Requirement costs for a system. Format C-1's for a set of National Requirements serve as inputs to a Format B-1 displaying NATO Requirements.

Format B-2 - The framework for displaying costs of the Common Production -- Sub-systems Only Procurement Strategy.

Format B-3 - The framework for displaying costs of the Parallel Multi-National Production Procurement Strategy.

Format B-4 - The framework for displaying costs of the Distributed Multi-National Production Procurement Strategy.

Format B-5 - The framework for displaying costs of the Specialization Production Strategy.

-Non-Recurring Production Costs - A cost category for those costs generally incurred only once during production of a weapon system. Included are the costs of plant facilities, tools, and test equipment.

- Recurring Production Costs - A cost category for those costs incurred during the manufacturing process. Included are manufacturing labor, recurring engineering, substaining tools, quality control, materials, project management and other cost elements. Army Pamphlet 11-3 dated April 1976 is an excellent discription of cost considerations for both non-recurring and recurring production costs.

- Integration and Assembly Costs - The recurring production costs associated with mating the sub-systems of a full system and final assembly. The effort involved is labor both on the assembly line and by engineers who insure that design changes in one sub-system are compatible with the mating process. This cost is usually included in the frame sub-system cost element. The frame sub-system in turn is usually the responsibility of the prime contractor.

- Technological Transfer Factor - A cost factor, which may be displayed as a percentage of a standard cost element, that represents industry experience in transfering design information from one country to another. A hypothetical example follows:

The ABC Company in the United States develops a new product at an R & D cost of $5,000,000 and Non-Recurring Production Costs of $5,000,000. The XYZ Company in Germany makes arrangements to produce this product and obtains a technical data package from ABC. In this particular industry, XYZ anticipates incurring expenses as follows - 15% of ABC's R & D costs plus 20% of ABC's non-recurring production costs plus 100% of ABC's non-recurring production costs prior to producing the first unit in Germany. The technological transfer factor is 15% R & D plus 20% non-recurring production.

III.

METHODOLOGY FORMATS

The methodology developed under this study for a comparative analysis of alternative production methods for meeting NATO requirements within a weapon system area provides cost comparisons under a set of assumptions described in Chapter II. This chapter describes the descriptive aspects of the methodology and Chapter IV depicts utilization techniques.

The Output Formats developed as part of this methodology permit a Department of Defense Decision Maker to examine in summary form a complete set of alternative procurement methods within the NATO community. These alternatives can vary in substance depending upon several factors. These are, according to weapon system area:

- Weapon system area and NATO requirement
- Status of technology
- Existing productive capability
- Existing labor pool
- Status of production on competing systems.

The policy question addressed by this methodology is one of economic choice between alternative procurement strategies. Economic choice is presented to the decision-maker in summary form by Format A. This is depicted in Figure III-1.

Format A presents comparative costs for each of the alternative procurement strategies considered within a particular scenario. It displays cost

FORMAT A
NATO Systems Cost Comparisons

1. System Family____________________ 2. NATO Requirement __________________

	1/ A	2/ B	3/ C	4/ D	E Savings _____vs A
3. System					
4. Program Cost					

1/ From Format B-1. National Initiative Procurement Strategy. (Designate Systems and quantities)

2/ From Format B-___. Specify system and give short description of procurement strategy

3/ From Format B-___. Specify system and give short description of procurement strategy

4/ From Format B-___. Specify system and give short description of procurement strategy

Figure III - 1

summaries and identifies cost savings in terms of the incremental cost of a national initiative procurement strategy over the least cost strategy. The costs for each alternative are based on identical quantities with the designated quantity representing the scenario's assumed NATO requirement.

Format B-1 collates cost and quantity information on weapon systems within the base case, or national initiative procurement strategy. This may be two or more weapon systems individually developed and produced by NATO member nations. The total quantity of systems produced is the NATO requirement. Format B-1 is depicted in Figure III-2. The total cost column sums the costs for the individual weapon systems and provides the cost input to column A of Format A. Specifically, the cost figure in Block 10 D goes to Format A.

Format C-1 is used to display useful cost information on the individual weapon systems. Each Format C-1 provides backup information for a weapon system cost display on Format B-1. If there are three systems in the national initiative procurement strategy, then there are three Format C-1's to support the B-1 display. Figure III-3 shows this format.

In addition to the cost display information (Columns C and D) on Format C-1, there is provided room for additional cost-related data. Column A records industry cost learning experience as expressed by learning curves. This information may be provided at the sub-system level. Column B lists the units by sub-system, to be produced under the national initiative scenario. This information is particularly significant if one or more sub-systems are already in production and are therefore further down the learning curve than other sub-systems. Column E provides a place to indicate the first unit cost

FORMAT B-1

NATO Systems Cost Comparisons

1. System Family ____________________ 2. NATO Requirement ____________________

	A	B	C	C	E Total Cost
3. System					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production Cost Element					
7.1 Frame					
7.2 Engine					
7.3 Weapon					
7.4 Weapon					
7.5 Ammunition					
7.6 Ammunition					
7.7 Communications					
7.8 Fire Control					
7.9 Electrical System					
7.10 Other (Specify)					
7.11 Other (Specify)					
7.12 Integration					
7.13 Recurring Flyaway					
7.14					
8. Peculiar Support Equipment					
9. Initial Spares					
10. TOTAL COSTS					

Figure III - 2

FORMAT C-1

NATO Systems Cost Comparisons

1. System ______________________ 2. Natl. Requirement ______________________

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost	E 1st unit cost
3. R & D					
4. Non-Recurring Production					
5. Recurring Production Cost Elements					
5.1 Frame					
5.2 Engine					
5.3 Weapon					
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Communications					
5.8 Fire Control					
5.9 Electrical System					
5.10 Other (Specify)					
5.11 Other (Specify)					
5.12 Integration					
5.13 Recurring Flyaway					
5.14					
6. Peculiar Support Equipment					
7. Initial Spares					
8. TOTAL COSTS					

Figure III-3

for recurring production of the system or sub-systems. With the information in Block 2 (National Requirement) and Columns A, B, and E, one can calculate costs for columns C and D. Ideally of course, the analyst has available more precise costs for Columns C and D from Military Service estimates.

Figure III-4 shows Format B-5. This format is closely related to Format C-1. Where, however, C-1 shows a national requirement quantity in Block 2, B-5 shows a NATO requirement. The costs in columns C and D of B-5 reflect this increase over the C-1 quantities. The total costs from Format B-5 (Block 8-C) is transferred to Format A. Note that when the analyst has completed Format B-5 for all competing weapon systems, he has a decision to make. Should Format A display the NATO requirement costs for all systems or just for the least cost alternative? The answer does not lie in methodology but rather in perception of the needs of the decision maker.

Formats B-1, C-1 and B-5 provide for data capture and aggregation of research and development, non-recurring production, and recurring production cost elements (i.e., 7.1 through 7.14 on Format B-1) have been generalized in this chapter. Elements 7.3 and 7.4 are labeled weapons. In an actual application where armament costs were considered relevant, the analyst should redesignate these elements to specify the armament system being used. The same logic applies in the ammunition elements. The cost element "communications" might better be labeled "avionics" for some systems. The same concept applies across the board.

Figure III-5 shows Format B-2. This format displays cost estimates for single country production of major sub-systems with multi-full system utility

FORMAT B-5

NATO Systems Cost Comparisons

1. System ______________________ 2. NATO Requirement ____________

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost
3. R & D				
4. Non-Recurring Production				
5. Recurring Production Cost Elements				
5.1 Frame				
5.2 Engine				
5.3 Weapon				
5.4 Weapon				
5.5 Ammunition				
5.6 Ammunition				
5.7 Communications				
5.8 Fire Control				
5.9 Electrical System				
5.10 Other (Specify)				
5.11 Other (Specify)				
5.12 Integration				
5.13 Recurring Flyaway				
5.14				
6. Peculiar Support Equipment				
7. Initial Spares				
8. TOTAL COSTS				

Figure III-4

Format B-2

NATO Systems Cost Comparisons

1. System Family ______________________

	A #Units	B	C	D	E
2. Country					
3. R & D					
4. Non-Recurring Production					
5. Recurring Production Cost Elements					
5.1 Frame					
5.2 Engine					
5.3 Weapon					
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Communications					
5.8 Fire Control					
5.9 Electrical System					
5.10 Other (Specify)					
5.11 Other (Specify)					
5.12 Integration					
6. Peculiar Support Equipment					
7. Initial Spares					
8. TOTAL COUNTRY COSTS					

9. TOTAL OF B, C, D, & E $__________

Figure III-5

(e.g. tank engines, tank guns, aircraft engines, military computers, etc.). This is an alternative production method that has the potential for economies of scale and learning while at the same time avoiding the political hazards of foregoing participation in production in a major weapon system area. In this procurement strategy, each participating country may incur R & D, non-recurring production and integration costs. The sub-systems however, are produced in only one country.

Utilization of Format B-2 is unique within the methodology in that only in exceptional cases would Format B-2 total costs be compared with other outputs. Rather, alternative Format B-2's would be developed for comparative purposes.

Block 1 of Format B-2 is used for system family description such as tactical air or tank. Block 2 is used to designate participating countries. In a Format B-2 scenario, participating countries would agree to purchase specific sub-systems from a single producer. The number of sub-systems is indicated in Column A. For example, it might be agreed that the FRG would produce engines for a family of NATO APCs. The designation FRG would go in Block 2B; the engine designation in Cost Element 5.2; and the total NATO requirement in Block 5.2 A. If Belgium were producing machine guns in this family, the designation Belgium would go in Block 2C; the specific machine gun designation in Cost Element 5.3, and the total NATO requirement in Block 5.3A.

It is possible that in an APC scenario, hulls would be built in more than one country. If for example, this were the case with the FRG and Belgium, Cost Element 5.1 would be expanded to have a 5.1a for the FRG and a 5.1b for Belgium. Other entries would follow the logic described above.

The comparative information of interest is in Rows 8 and 9. Row 9 shows total cost for a cooperative agreement. This is broken out by country in Row 8.

Format B-3 is dedicated to displays of cost estimates where the selected production method provides for multi-production sites for a single weapon system. The economic potential here is a derivative of technological transfer within a multi-national production agreement. This is displayed as Figure III-6.

Data for completing Format B-3 would be from the Format C-1 on the system in question. Agreement is reached to produce one system through licensing or other arrangements. Only one country incurs R & D expense. Non-recurring production expenses and recurring production expenses are incurred by all participating countries. All countries but the developer incur the cost of transferring the technology to their industry. This cost may vary from country to country and is entered in Blocks 10 B, C, and D (if there are three participating countries in addition to the developer).

Format B-4 displays cost estimates for a production method where a complete system is produced within a single country with multi-national assembly. This is shown as Figure III-7.

The system is designated in Block 1; the total quantity to be produced in Block 2. Block 3A designates the developer. This country incurs costs for R & D, non-recurring and recurring production. This data is provided from Format B-5 and is used in Blocks 5A, 5B and 5C (The 5-C entry is from Block 5B of B-5). Cost elements 5, 6 and 7 have no entries for participating countries B, C, and D.

FORMAT B-3

NATO Systems Cost Comparisons

1. System ______________________________ 2. NATO Requirement ______________________

	A	B	C	D	E Totals
3. Country					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production Cost Elements					
7.1 Frame					
7.2 Engine					
7.3 Weapon					
7.4 Weapon					
7.5 Ammunition					
7.6 Ammunition					
7.7 Communications					
7.8 Fire Control					
7.9 Electrical System					
7.10 Other (Specify)					
7.11 Other (Specify)					
7.12 Integration					
7.13 Recurring Flyaway					
7.14					
8. Peculiar Support Equipment					
9. Initial Spares					
10. Technological Transfer Factor					
11. Total Costs					

Figure III-6

FORMAT B-4

NATO Systems Cost Comparisons

1. System ____________________ 2. NATO Requirement ____________________

	A	B	C	D	E Cost Extension
3. Country					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production					
8. Overseas Integration Set aside					
9. Other Production Costs					
10. Integration Factor					
11. Integration Costs					
12. Total Costs					

Figure III-7

The developing country does not assemble all the units that it produces. The quantity assembled is entered in Block 4A. The quantities assembled in other countries are appropriately entered in Blocks 4B, 4C and 4D. The total of 4A, 4B, 4C, and 4D should equal the Block 2 entry.

Since the integration costs included in Block 7A are for the total quantity produced, this entry is too high. A set aside is required. This is the difference between the assembly and integration costs on the Formats C-1 and B-5 for the system under consideration (Format B-5 block 5.12 C less Format C-1 Block 5.12 C). This is entered in Block 8A and is a negative entry.

The Block 9A entry is total of Block 6C and 7C from Format B-5 on the appropriate system.

Blocks 10B, C, and D are for information, not costs. Expert opinion should be brought to bear to establish this factor. If country B is assemblying sub-systems made elsewhere, their integration is probably less efficient than assembly by the producing prime contractor. They are also starting at the top of the integration labor learning curve. The factor is entered in Blocks 10B, C, and D and the corresponding costs in the blocks in Row 11. Total costs are calculated and the cost figure from Block 12E is entered on Format A.

A Data Collection Sheet has been developed and is displayed as Figure III-8. Since data collection formats are particularly unique to analysis purposes, this format will in practice vary with specific investigations. The principal point to be borne in mind is that the data is collected on each identified sub-system.

NATO COST METHODOLOGY - Data Collection Sheet

1. ____________ (Subsystem)

2. ______________________________ (system or systems subsystem is part of)

3. __________ (quantity)

4. ______________________________ (timeframe)

5. Physical Characteristics:
   a.
   b.
   c.
   d.
   e.

6. Performance Characteristics:
   a.
   b.
   c.
   d.
   e.

7. Direct Labor Hours, 100th unit — (Hours) ______________________ (Monthly Production Rate)

8. Direct Labor Hours, 400th unit — (Hours) ______________________ (Monthly Production Rate)

9. Direct Labor Hours, 800th unit — (Hours) ______________________ (Monthly Production Rate)

10. Material Costs, 100th unit — (Amount) ______________________ (Unit by year) (i.e. 1977 dollars)

11. Material Costs, 400th unit — (Amount) ______________________ (Unit by year)

12. Material Costs, 800th unit — (Amount) ______________________ (Unit by year)

13. Industry Cost Learning Curve ______ %

14. Industry Labor Learning Curve ______ %

15. Integration, as percent of assembly labor ______ %

16. Facility Name ____

17. Facility Location ____

18. Date facility became operational ________________________

Figure III-8

19. Facility Capacity, 1 shift ______________________
(Shift Description 8-5)

20. Subsystem Cost Estimate ______________________

21. Subsystem Cost Estimate ______________________

22. Subsystem Cost Estimate ______________________

23. Subsystem Cost Estimate ______________________

24. Subsystem Cost Estimate ______________________

25. CER plus data base (attach) ______________________

26. CER plus data base (attach) ______________________

27. CER plus data base (attach) ______________________

Source Information, NATO Cost Methodology

Page 1, Line II	Document, Classification, Date, Location Found
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	
16.	
17.	
18.	
19.	
20.	
21.	
22.	
23.	
24.	
25.	
26.	
27.	

IV

METHODOLOGY UTILIZATION

This methodology for measuring the potential cost savings through selection of a procurement strategy for weapon system standardization or specialization for NATO member nations offers the United States policy makers a unique capability for evaluation of alternative economic choices early in the weapon system acquisition process. The uniqueness lies in two areas; rapid response and consistency in treatment of cost elements. This consistency helps to insure that the relative cost differences between alternative procurement strategies will be valid for screening purposes, even if cost uncertainties exist.

The methodology presents, in the weapon systems area, a total investment cost by specific system, to cover each national initiative within the area. Unit totals aggregate to the NATO requirement and cost totals aggregate to the probable NATO expenditure under this base line assumption. The problem solution, i.e., potential savings through a cooperative approach in the acquisition of weapon systems, is a cost decrement by an alternative production strategy without decrementing units. The maximum savings potential would be agreement prior to significant R & D expenditures to develop and produce the least cost alternative national system in a quantity equal to the total NATO need. The cost of this alternative can be computed by extending, via industry, cost/quantity relationships, the recurring production costs, and by adding system R & D and non-recurring costs. While this identifies maximum potential savings, it violates the politico-economic assumption that industrial nations are inclined to sacrifice optimum weapon system investment strategies in order to preserve their technological and industrial base. The objective, therefore, is to derive second and third best economic solutions.

Figure IV-1 depicts, in a general way, the cost spread between a national initiative scenario of three systems and a specialization scenario with an early decision for NATO to adopt a single system. The hypothetical NATO need is for 5,000 units and each scenario procures that quantity. The national initiative scenario, however, expends funds in R & D, and facilities for systems Y and Z, while the specialization scenario does not. Other savings are a product of recurring production learning. The production costs as depicted here imply a relatively flat learning curve. This may or may not be the case when a specific system family is examined. A steeper learning curve, extending throughout a production run of 5,000 units, would increase cost savings.

In examining potential savings to NATO member nations of alternative procurement strategies, an analyst can hypothesize strategies that should result in investment costs that fall between the two extremes and provide incentives for multi-national cooperation. The generalized incentive considered here is one that employs the technological and industrial bases of more than one NATO member country.

Consider Figure IV-2. X_1 continues to depict a specialization scenario for producing 5,000 units of System X. Total cost is $4 billion. X_2 depicts development, facilities, and production of the same system less a major component. X_E depicts development, facilities, and production of the major component in another NATO country. The sum of X_2 and X_E R & D costs is greater than X_1 R & D, since the exchange of information is assumed to exceed the information need under the specialization scenario. The same factor will probably cause an increase in production costs.

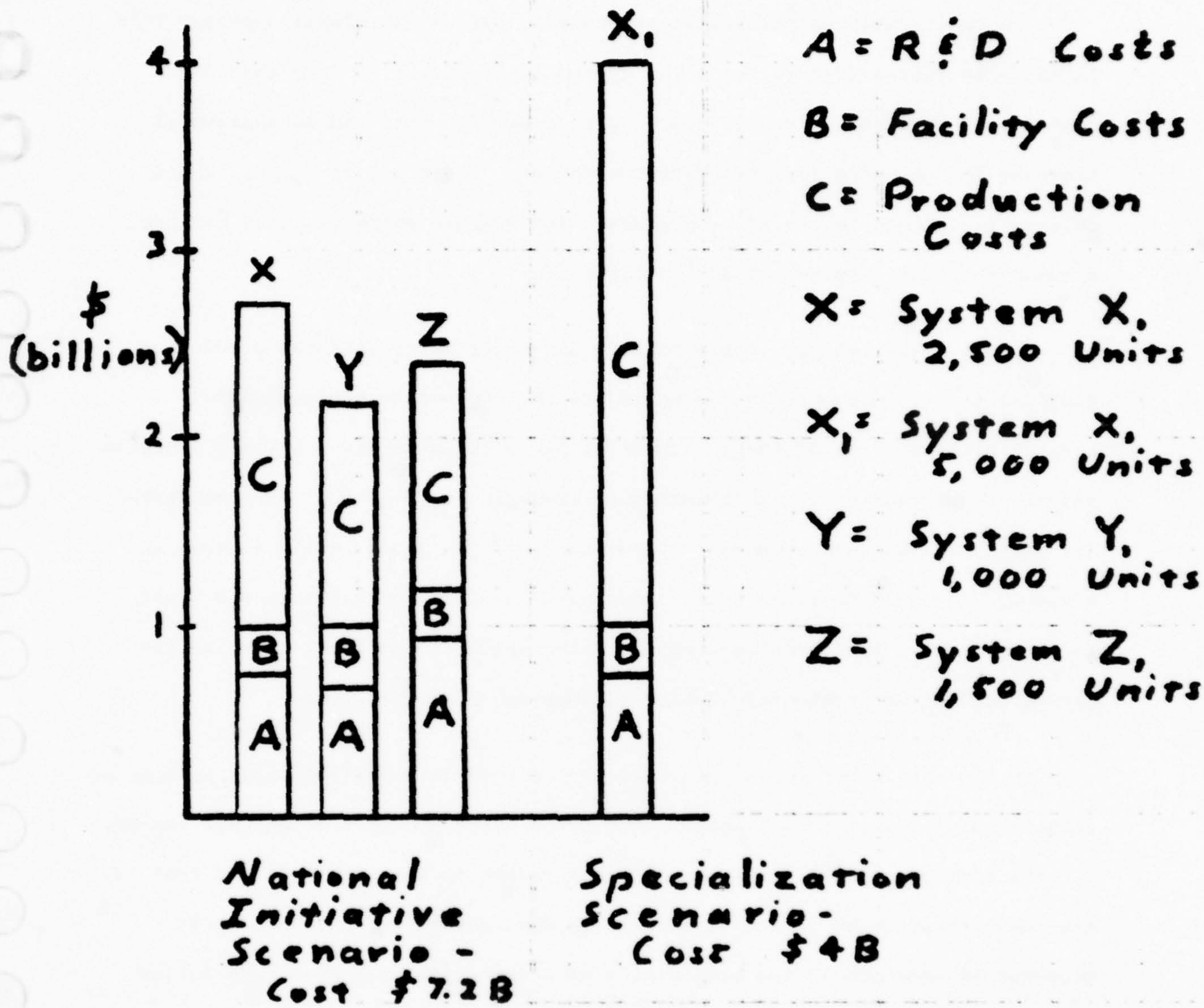


FIGURE IV-1

Generalized Comparison of Investment Cost Range for Alternative Procurement Strategies

The multinational participation scenario has an additional aspect. This is shown in Figure IV-2 as "D." The system is assembled in more than one country. This means a loss of learning on assembly costs and an additional increase in the need for information exchange. The total of X_2, X_E, amd D dollars is assumed to exceed X_1 dollars. For graphic purposes, this has been assumed to be an increase of $750 million.

Figure IV-2 also provides a takeoff for other multi-national production possibilities. Suppose only two nations were involved in production but several nations utilized their industrial bases for assembly. D would increase and the total cost of the multi-national scenario would go up. Suppose three (or more) nations were engaged in production, but only one nation engaged in assembly. D would decrease while there might well be increases in R & D and facility costs. A methodology for examining the cost implications of alternative production strategies should consider these implications.

In its more general sense, a cost methodology is a precise specification of relationships enabling cost information to be expressed in a meaningful manner. In this instance, "meaningful manner" must relate to the problem area; that is, the identification of potential savings to NATO member nations through a cooperative approach in the acquisition of weapon systems. From this follow specific information requirements. These include:

- Identification of NATO need for weapon systems
- Identification of subsystems
- Identification of learning potential
- Identification of cost impact of transferring technological information (such as a technical data package) from one country to another
- Identification of integration and assembly costs and associated learning.

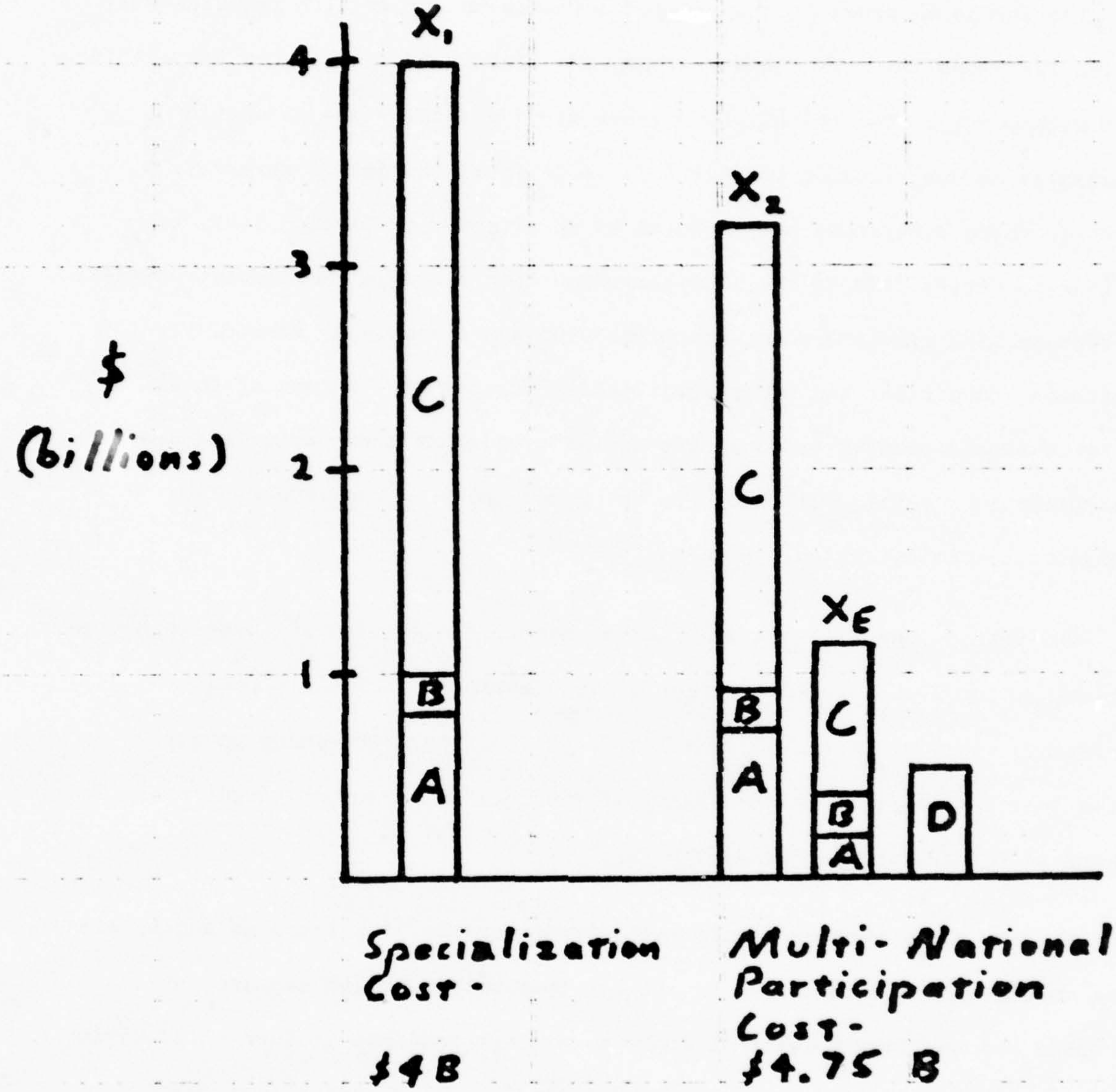


FIGURE IV-2

Generalized Comparison of Alternative NATO Procurement Strategies

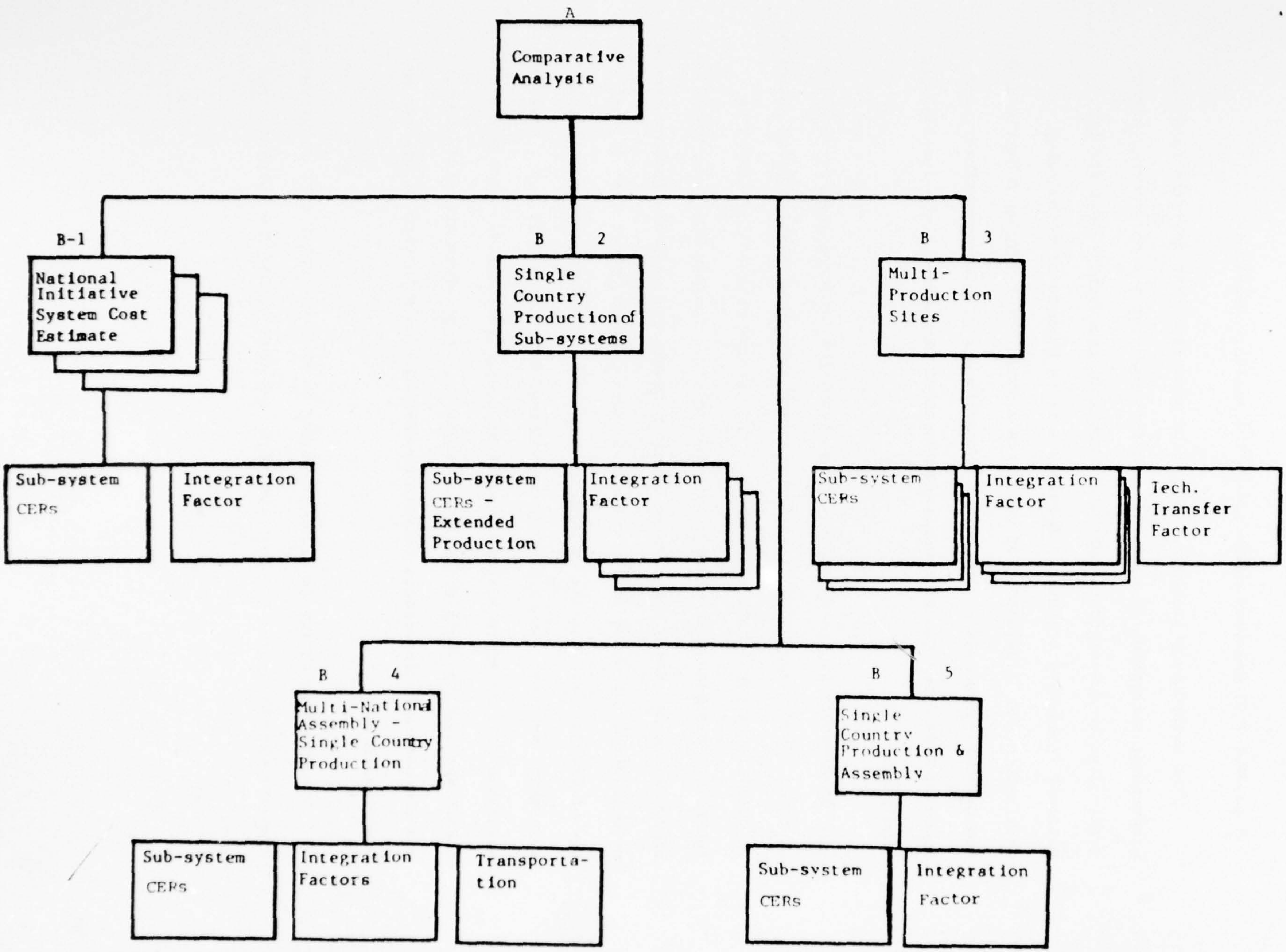
The foregoing provides generalized guidance on information requirements. Figure IV-3 displays this concept within the context of an expanded comparative cost methodology. This methodology looks at five alternative production strategies as described in Chapter III: a national initiative strategy; a strategy where subsystems are produced on an extended production line, but various countries produce the subsystems and then assemble the complete system; a strategy of a single system with production and assembly by several participating countries; and two specialization strategies. In one of these latter a single country produces the entire system but integration and assembly take place in several countries. In the other there is complete system acquisition specialization.

The methodology will not provide the detailed cost estimate used in source selection, nor even a validity check of such estimates. It is a policy-assistance tool, not a cost estimating format. It is a screening device. These features appear to be necessary if the tool is to support decision makers in the environment of NATO policy.

The tool also generates information requirements at a level of aggregation that should be more responsive to inquiry than more detailed requirements. European and American industrial concerns are not inclined to furnish specific cost information on learning curves and technological transfer; but this information at the industry level tends to lose its proprietary aspects. In addition, industry data can be collected in advance, while specific data requirements in these areas are dependent upon identification of proposed facilities. A policy office interested in using this methodology should initiate data collection of learning curves by industry within each NATO member nation and technological transfer cost data by industry. In addition, a data bank of integration and assembly costs could be developed by examination of

FI[illegible] I[illegible]

[illegible]mpara[illegible]ive Co[illegible] Meth[illegible]olog[illegible]



independent cost analyses conducted by the military services.

This methodology presupposes a set of scenarios that describe feasible procurement strategies in terms of specific competing weapon systems, a NATO requirement in quantitative terms, and probable procurement buys for the national initiative scenario. Appendix A is an example of methodology utilization for a screening of candidate systems for a NATO main battle tank requirement. Appendix B considers a ground-to-air missile competition, and Appendix C examines two alternative procurement strategies for a tactical air requirement.

In Appendix A, a comparison is made between a national initiative scenario of three tank systems, and three scenarios of individual systems being selected to fulfill the total NATO requirement. The Interim Format A developed in Appendix A has been deliberately left incomplete. In this exercise, the analysis has reached a point where scenario discussion with the sponsor should be considered. Looking at the interim results one can deduce that an XM-1 buy of 21,000 units for all of NATO does not offer savings over a national initiative scenario. Some savings are offered by a Leopard II buy. However, available data on non-recurring production costs are suspect. Note how the full format was used to highlight all cost elements. Ammo costs are also suspect and the combined differences between an XM-1 buy and a Leopard II buy can be explained here.

The economic choice is a Chieftain buy to meet the total NATO requirement. However, the Chieftain is a less powerful tank than either the Leopard II or the

XM-1. This consideration is another reason for suggesting scenario revision.

Interaction with the policy staffs might proceed along the following lines:

Analysis to date suggests no significant savings by a total XM-1 solution. A total Leopard II solution may offer savings but of less than 10%. The Chieftain should probably not be in the scenario set other than as part of a national initiative (base case) scenario. It seems probable that no significant savings are to be found in this area.

Appendix B is a display of methodology application where data availability is limited. There is no readily identified alternative to the Patriot. The real question then becomes; could an alternative be developed without incurring substantial economic penalty? The answer seems to be "No." Therefore, the Patriot is a logical candidate for NATO specialization.

Appendix C considers a tactical aircraft requirement for the United States and four other NATO nations. The example used is the F-16 vs. the Mirage. In this case we know the potitical solution which is an integrated production agreement and multi-national participation at W B S levels below the subsystem. The methodology treated this as single country production using U.S.A.F. cost data. The National Initiative scenario treated the Mirage as a European candidate and the F-16 as a U.S. candidate.

The interesting feature of the analysis is the significant cost savings indicated. The actual solution as negotiated in 1975 represents a substantial cost savings to the NATO countries over the only other likely procurement strategy; the national initiative alternative.

Appendices A, B, and C offer some limited insight into full methodology utilization. It is important that realistic scenarios be developed wherein potential procurement strategies are delineated. Given such a framework, the methodology is a powerful tool for display, screening, and policy assistance.

V

METHODOLOGY DESCRIPTION

This chapter describes the cost comparison methodology developed for the Office of the Secretary of Defense for quantifying the potential net economic consequences of increased NATO commonality, standardization, and specialization. The methodology consists of basic building blocks, two sets of procedures, and a set of output formats. These are described in sequence in the following paragraphs. Figure V-1 displays a generalized view of the methodology.

The basic building blocks required for this comparative methodology are:

1. The Military Service Cost estimate by major subsystem for all systems under consideration.
2. Integration factors, by country by industry at the system level.
3. Learning curves by industry by country.
4. Subsystem statistical cost estimating relationships for system cost categories and subsystems.

The set of procedures that permit the development of a comparative cost analysis for alternative methods of procurement are:

STAGE I

1. Selection of candidate system family (Main Battle Tanks, Tactical Fighters, etc.).

2. Identification of candidate systems for cost comparison (XM-1, Leopard II, Chieftain, etc.).

3. Identification of major subsystems within each candidate system.

4. Specification of Military Service cost estimate for each subsystem (Building Block 1).

5. Specification of industry learning curve for each subsystem (Building Block 3).

6. Examination of possible alternative methods of production (Formats B-1 through B-5 as described in Chapter III) and elimination of unreasonable alternatives.

7. Structure Formats C-1, B-1 and B-5 with specific cost categories for selected systems.

8. Establish system quantities for Formats B-1 and B-5. (Total quantities are identical and are NATO, including U. S., requirements).

9. Input learning curves by subsystem on Format B-5 (Separate Format B-5's are completed for each system).

10. Input integration factor on Format B-5's.

11. Input system quantities for Format C-1 from individual system quantities on Format B-1. Input learning curves and integration factors (from B-5's).

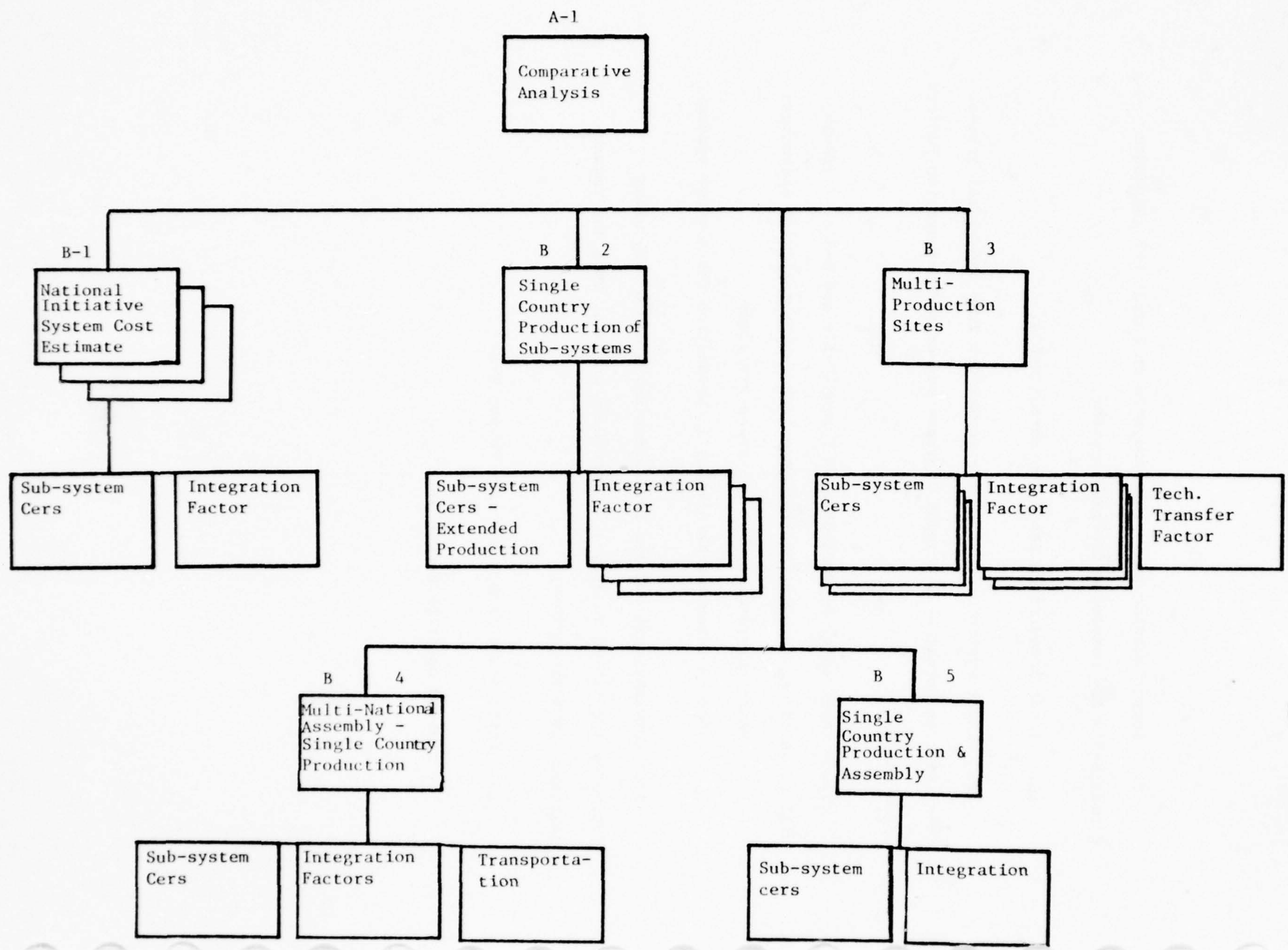
12. Input units by subsystem on Format C-1's and B-5's. (These will be units one through requirement except in the following instances:

- where subsystem spares are to be included;
- where a subsystem is already in production for another system).

13. Complete cost entries for Format B-5's and C-1's, using estimates identified in Step 4. Depending on data, this may require learning curve extensions.

14. Enter costs from C-1's onto Format B-1.

15. Extend costs on Format B-1.


A-1
Comparative Analysis
B-1
National Initiative System Cost Estimate
Sub-system Cers
Integration Factor
B 2
Single Country Production of Sub-systems
Sub-system Cers - Extended Production
Integration Factor
B 3
Multi-Production Sites
Sub-system Cers
Integration Factor
Tech. Transfer Factor
B 4
Multi-National Assembly - Single Country Production
Sub-system Cers
Integration Factors
Transportation
B 5
Single Country Production & Assembly
Sub-system cers
Integration

DISCUSSION

Step 15 completes Stage I of the procedures. The analyst now has a completed Format B-1 and a completed Format B-5 for each competing system. Format B-1 shows the investment costs for a NATO posture where each NATO member with interest and capability has developed and produced its own system. The total quantity produced represents the NATO requirement. This can include assumptions of intra-NATO sales; i.e., a Netherlands buy of Leopard IIs and an Italian buy of XM-1's would be included under the appropriate system costs. Cost backup for each system is provided by the appropriate Format C-1.

For each competing system there is a completed Format B-5. This format displays costs for a scenario where the entire NATO requirement was produced by a single country. Therefore, in the Main Battle Tank scenario, there are separate Format B-5's for each competing tank: XM-1, Leopard II, and Chieftain.

An Interim - Format A can now be prepared that can be interpreted as showing the possible range of costs. It is hypothesized that the total cost for the alternative depicted by Format B-1 is normally the most expensive alternative and that the least expensive of the Format B-5 alternatives will normally show the economically-preferred alternative system. TABLE V-1 displays this potential.

INTERIM FORMAT A-1

	B-1	XM B-5(M)	LEOPARD II B-5(L)	CHIEFTAIN B-5(C)	SAVINGS B___ over B-1
TOTAL COSTS					

TABLE V-1
MAXIMUM SAVINGS AND
RANGE OF COSTS

FORMAT B-1

NATO Systems Cost Comparisons

1. System Family____________________ 2. NATO Requirement ____________________

	A	B	C	C	E Total Cost
3. System					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production Cost Element					
7.1 Frame					
7.2 Engine					
7.3 Weapon					
7.4 Weapon					
7.5 Ammunition					
7.6 Ammunition					
7.7 Communications					
7.8 Fire Control					
7.9 Electrical System					
7.10 Other (Specify)					
7.11 Other (Specify)					
7.12 Integration					
7.13 Recurring Flyaway					
7.14					
8. Peculiar Support Equipment					
9. Initial Spares					
10. TOTAL COSTS					

FORMAT C-1

NATO Systems Cost Comparisons

1. System ______________________ 2. Nat l. Requirement ________________

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost	E 1st unit cost
3. R & D					
4. Non-Recurring Production					
5. Recurring Production Cost Elements					
5.1 Frame					
5.2 Engine					
5.3 Weapon					
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Communications					
5.8 Fire Control					
5.9 Electrical System					
5.10 Other (Specify)					
5.11 Other (Specify)					
5.12 Integration					
5.13 Recurring Flyaway					
5.14					
6. Peculiar Support Equipment					
7. Initial Spares					
8. TOTAL COSTS					

FORMAT B-5

NATO Systems Cost Comparisons

1. System ______________________________ 2. NATO Requirement _______________

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost
3. R & D				
4. Non-Recurring Production				
5. Recurring Production Cost Elements				
5.1 Frame				
5.2 Engine				
5.3 Weapon				
5.4 Weapon				
5.5 Ammunition				
5.6 Ammunition				
5.7 Communications				
5.8 Fire Control				
5.9 Electrical System				
5.10 Other (Specify)				
5.11 Other (Specify)				
5.12 Integration				
5.13 Recurring Flyaway				
5.14				
6. Peculiar Support Equipment				
7. Initial Spares				
8. TOTAL COSTS				

STAGE II

This Stage of the comparative cost methodology deals with three additional alternative production methods. Format B-1 and its Format C-1 backup display the essential information for subsequent analysis. Inherent in the Stage I methodology is the identification of specific building block information that was captured on Format C-1 for each system in contention and consolidated in Format B-1 to display an investment cost profile without the potential economic advantages of procurement specialization or system standardization.

The three additonal alternative production methods being considered are:

- A production alternative where there is subsystem specialization within the production of national initiative systems. To use the main battle tank systems as our example: the U.S. produces the XM-1; the FRG produces the Leopard II; and the United Kingdom the Chieftain; but in contrast to a completely independent role for each nation, there is agreement to implement a subsystem interchange. Perhaps the Germans use the U.S. turbine, and the U.K. and the U.S. use the FRG gun. Format B-2 is used for this scenario.

16. Identification of System Family and competing systems. Complete items 1 through 3 on Format B-2.

17. Specification of subsystem specialization to be considered (i.e., turbine and gun).

18. Input to Format B-2 under column A, the total NATO requirement for the specialization subsystems.

19. Block out the cost columns for the non-producing countries on the specialization subsystems (i.e., if FRG is using the U.S. turbine there will be no costs for item 5.2 (engines) in the Leopard II column).

20. Make all entries in columns A, B, C, D, and E for Recurring Production, Rows 5.1 through 5.12. The specialization subsystems (i.e., turbine and gun costs) are on appropriate Format B-5's. The other subsystem data is on appropriate Format C-1's.

21. If specialization subsystems are not in production, there may be reductions in Format B-2 inputs for R & D and non-recurring production costs (Rows 4 and 5) from costs shown on Format B-1. These reductions for the columns (B or C or D) representing the countries not producing the subsystem can be made on a percentage basis.

Format B-2

NATO Systems Cost Comparisons

1. System Family ______________________

	A #Units	B	C	D	E
2. Country					
3. R & D					
4. Non-Recurring Production					
5. Recurring Production Cost Elements					
5.1 Frame					
5.2 Engine					
5.3 Weapon					
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Communications					
5.8 Fire Control					
5.9 Electrical System					
5.10 Other (Specify)					
5.11 Other (Specify)					
5.12 Integration					
6. Peculiar Support Equipment					
7. Initial Spares					
8. TOTAL COUNTRY COSTS					

9. TOTAL OF B, C, D, & E $__________

22. Extend remaining cost elements and compute total costs for this alternative production method.

23. Enter Format B-2 data on Format A.

24. Enter Format B-1 data on Format A and compute cost savings from Format B-2 production alternative.

Format B-3 displays another production alternative. This method provides for multi-production sites for a single weapon system. This is the co-production alternative.

25. Select System Family and system to be produced. Enter items 1 through 3 on Format B-3.

26. Column A represents the country developing the system, columns B and C countries that will co-produce. Enter items 4 and 5. The total (extension) of quantity to be produced should equal NATO requirement.

27. Enter costs for Column A system from appropriate Format C-1.

28, Enter Technological Transfer Factor from data bank for items 10 - B and C.

29. Compute Total Recurring Production costs for columns B and C.

FORMAT B-3

NATO Systems Cost Comparisons

1. System ______________________ 2. NATO Requirement ________________

	A	B	C	D	E Totals
3. Country					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production Cost Elements					
7.1 Frame					
7.2 Engine					
7.3 Weapon					
7.4 Weapon					
7.5 Ammunition					
7.6 Ammunition					
7.7 Communications					
7.8 Fire Control					
7.9 Electrical System					
7.10 Other (Specify)					
7.11 Other (Specify)					
7.12 Integration					
7.13 Recurring Flyaway					
7.14					
8. Peculiar Support Equipment					
9. Initial Spares					
10. Technological Transfer Factor					
11. Total Costs					

FORMAT B-4

NATO Systems Cost Comparisons

1. System ______________________ 2. NATO Requirement ________________

	A	B	C	D	E Cost Extension
3. Country					
4. Quantity					
5. R & D					
6. Non-Recurring Production					
7. Recurring Production					
8. Overseas Integration Set aside					
9. Other Production Costs					
10. Integration Factor					
11. Integration Costs					
12. Total Costs					

30. Enter Non-recurring Production costs for items 7 B and 7 C as appropriate percentage of items 9 B and C. (See data bank)

31. Calculate items 11 A, B and C. Extend to 11 D. 11 A is sum of 6A, 7A and 9A. 11B is sum of 7B and 9B. 11C is sum of 7C and 9C.

32. Transfer 11D (and subordinate cost elements 6D, 7D and 9D to Format A.

33. Compute cost savings from Format B-3 production alternative.

Format B-4 displays another production alternative. This method of NATO standardization provides for single-country production of sub-systems which are then shipped to various countries for assembly.

34. Select System Family and system to be produced. Enter items 1 and 2 on Format B-4.

35. Establish producing country and assembly countries. Enter producing country name in 3A; enter assembling countries in 3B and 3C.

36. Establish quantities to be assembled by country. Enter in row 4. Total (4D) should equal NATO Requirement.

37. From Format B-5 enter items 5A, 6A, and 7A.

38. Based on cost element 5.12 in Format B-5, which assumed integration and assembly of total NATO requirement and quantity to be assembled in producing country (item 5A in Format B-4), calculate overage in recurring production element and enter as 9A.

39. Subtract 9A from 8A and enter as 10A.

40. Enter appropriate national integration and assembly factors from data bank in items 11B and 11C.

41. Compute integration and assembly costs and enter in 12B and 12C.

42. Calculate costs by country and extend to column D.

43. Transfer items 6D, 7D, 10D and 13D to appropriate entries on Format A.

FORMAT A
NATO Systems Cost Comparisons

1. System Family____________________ 2. NATO Requirement ____________________

	A 1/	B 2/	C 3/	D 4/	E
3. System					
4. Program Cost					Savings _____vs A

1/ From Format B-1. National Initiative Procurement Strategy. (Designate Systems and quantities)

2/ From Format B-___. Specify system and give short description of procurement strategy

3/ From Format B-___. Specify system and give short description of procurement strategy

4/ From Format B-___. Specify system and give short description of procurement strategy

The foregoing has set forth the steps required in the preferred procedure of the cost comparison methodology. This procedure uses basic building blocks as identified earlier. The possibility exists that for a particular OSD requirement to exercise the methodology, certain systems will be considered where the Military Services do not have cost estimates. The ideal solution is to postpone exercising the cost comparison methodology until the competent echelons of the interested Service can develop an estimate. It may not, however, be feasible to postpone initial consideration of procurement strategy alternatives. In this instance, subsystem statistical cost estimating relationships can be used to develop approximate costs. These CERs (basic building block 5) could thus be used as a fallback position in the methodology.

The fallback position in the methodology is used when there is no Service estimate or other source of acceptable estimates to develop subsystem cost estimates for input into Format C-1. It could also be used as a source of entry data for Format B-5.

The procedure step involved is Step 4. The CERs are used to develop a subsystem cost instead of a Military Service cost estimate.

It should be noted that this use of CERs is not procedurally inferior to the use of Military Service cost estimates. It will, however, take more time, even if the data bank (Appendix D) requirements have been met.

APPENDIX A

This appendix is the principal appendix of the study since it illustrates the spectrum of methodology employed for the three types of weapon systems which were studied: main battle tanks, ground-to-air missiles, and tactical manned aircraft. Due to the availability of main battle tank data, the computation of costs for the XM-1, the Leopard II and the Chieftain had to be approached in different ways and a variety of methods employed to determine both overall system costs and component/cost element costs. Detailed information concerning methodology is provided as the backup to the Formats B-5 and C-1. The most comprehensive backup information is provided for the XM-1 tank equipped with the 105mm gun at the NATO assumed quantity of 21000 tanks.

The methodology of the study falls into four general categories which are listed in the order of their desireability:

1. Use of a military service cost estimate. Recent state-of-the-art for U.S. military cost estimates (mandated by OSD) permits the use of parametric cost estimating techniques to develop and/or support the military service cost estimate. The parametric cost estimating techniques normally include the use of Cost Estimating Relationships (CER) with their appropriate learning/cost curves and cost factors based on experience. Cost gaps in the parametric techniques are then normally filled by use of expert opinion by engineers and cost estimators, industry or military service estimates based upon the actual cost of items currently being produced, and evaluation of activities such as project management and plant overhead.

2. Accumulation of actual or estimated costs from various sources. This approach requires careful evaluation of accumulated costs for validity and consistency. Normally, it also requires use of appropriate cost curves to further refine costs, development of estimates to cover cost gaps which occur when varied data sources are used, and extension of costs to represent quantities of items which are different from those cited in the original data sources.

3. Use of CERs. Existing parametric estimating techniques are applied to develop cost estimates when no actual/estimated cost data is available from existing sources of information. Learning/cost curves are an integral part of this technique. Physical/performance characteristics of the weapon system are used to develop the cost estimates by inserting them into a CER and calculating the resulting costs. Expert opinion is used to confirm the validity of these estimates.

4. Use of military service cost estimates which are not supported by conventional cost estimating techniques. Many times these techniques are not available due to lack of supporting data or due to state-of-the-art advances in weapon systems which make existing cost estimating techniques obsolete. Estimates might then be developed using labor hours with appropriate labor learning curves and material amounts/quantities with material learning curves.

In the case of the main battle tanks, the first three techniques are all used to some degree. The fourth technique, use of labor and material learning curves, was not used. This is merely a more detailed version of cost curve methods. Methodology used in preparing the various estimates is explained in detail in the backup to the Formats B-5 and C-1.

A summary of the methodology used to estimate the costs for each of the main battle tanks illustrates the techniques used:

1. 7058 XM-1 equipped with the 105mm gun. Costs were obtained from the XM-1 Project Manager's Baseline Cost Estimate (BCE) of May 1978. They were then distributed among the XM-1 components/cost elements on a percentage basis which was developed from an Army Cost Analysis Paper (ACAP) for the XM-1 tank system and published on 30 May 1976.

2. 21000 XM-1 equipped with the 105mm gun. Costs were developed using the BCE data and ACAP parametric cost estimating techniques (CER) to extend the XM-1 quantity to the assumed NATO quantity of 21000 XM-1. Expert opinion was used in selected cases to reject some CER generated parametric estimates and to accept BCE estimates.

3. 7058 XM-1 equipped with the 120mm gun. Costs were obtained from the BCE, distributed among the components/cost elements on a percentage basis derived from the ACAP, and extended by cost factors to represent costs for all XM-1 tanks equipped with the 120mm gun.

4. 21000 XM-1 equipped with the 120mm gun. Costs were obtained from the BCE data and from estimates developed for the 21000 XM-1 with the 105mm gun and the 7058 XM-1 equipped with the 120mm gun. Cost factors were used to extend costs to the desired quantity of 21000 XM-1 with the 120mm gun. Expert opinion was again employed to accept/reject the resulting costs.

5. Leopard II. Industry estimates of the unit cost for the U.S. production of Leopard II were used. The unit cost was then distributed among components/cost elements on the same basis as that used to distribute the XM-1 costs. The costs of the desired quantities were computed by extending the unit cost figures. Lack of information prevented development of Leopard II production costs in the FRG. Non-recurring production costs in the FRG and

FRG R&D costs were likewise unavailable and could not be estimated by currently known techniques.

6. Chieftain. The Chieftain estimate was the most limited of all. Only a single unit cost figure was available. It is not known what was included in that figure. The resulting cost figures are consequently suspect in scope, in distribution among recurring production costs, and between recurring and non-recurring production costs. However, the unit cost figure was assumed to represent recurring production costs and distributed among the components/cost elements on the same basis as that used to distribute XM-1 costs. Costs were computed by extending unit costs to the desired 1000 and 21000 quantities. R&D and non-recurring production costs are unknown and could not be estimated by currently known techniques.

Production quantities used in the study represent:

1. XM-1.
   a. Currently authorized U.S. production quantity of 7058.
   b. Assumed NATO quantity of 21000.
2. Leopard II.
   a. NATO assmmed quantity of 21000 minus the U.S. production quantity of 7058 and U.K. production quantity of 1000. (21000 - 7058 - 1000 = 12942).
   b. NATO assumed quantity of 21000.
3. Chieftain.
   a. Estimated U.K. production of approximately 1000.
   b. Assumed NATO quantity of 21000.

These quantities are assumed, not actual, to avoid classification of the study.

Cost figures obtained for the study were in FY 1972, FY 1976 and FY 1979 dollars. All dollars were converted into FY 1979 dollars using inflation factors provided in the Budget Review Committee Memorandum of 28 Jan 1978 prepared by Comptroller of the Army, Hq, DA. In the case of the Chieftain, the U.S. unit cost figure was inflated at rates obtained from general U.K. economic inflation indices.

Formats C-1 have been completed to represent the national requirements for the XM-1, Leopard II and Chieftain. Format B-1 was then completed by using the Format C-1 data. Format B-1 consolidates the national requirements shown in the Formats C-1 for the XM-1, Leopard II and Chieftain and shows the total cost to NATO when all three systems are produced. Formats B-5 were then prepared for the XM-1, Leopard II and Chieftain in order to show the relative costs of a single country producing the entire NATO quantity. Format B-5 and B-1 costs were then entered on Interim Format A to provide a ready cost comparison of alternative production methods.

It must be reiterated that the purpose of this study is not to develop actual cost estimates for each type of weapon system, but is designed to provide useable methods to compare and evaluate production alternatives. The main battle tank portion of the study illustrates how the methodology may be applied. It also portrays the strengths and weaknesses of the various estimating techniques. Time limits of the study prevent further exploration of the methods used and the possible capture of additional data for the Leopard II and Chieftain. Additional work is required in those areas to further refine the methodology and provide more viable weapon system comparison

techniques. In particular, specific answers are required in the area of weapon system integration costs, both when the entire weapon system is produced by a single country and when components/cost elements are produced by a single country for integration into other nations own weapons systems, e.g., 120mm gun for the XM-1 tank. Fully valid comparisons of weapon system production alternatives are not possible until these additional areas are explored and refined.

INTERIM FORMAT A
NATO Systems Cost Comparisons

1. System Family Main Battle Tank 2. NATO Requirement 21000*

	A[1] (FY1979M$)	B[2] (FY1979M$)	C[2] (FY1979M$)	D[2] (FY1979M$)	E
3. System	XXX	XM-1 (120mm gun)	LEOPARD II	CHIEFTAIN	XXXX
Cost Elements					Savings vs A
4. R & D	861.1	748.1	283.9	XXX	
5. Non-Recurring Production	1375.6	1942.6	731.9	XXX	
6. Recurring Production	19030.8	18696.0	18571.3	10772.2	
6.1 Frame	7853.9	6315.1	7664.2	4445.6	
6.2 Engine	2959.0	1407.6	2887.5	1674.9	
6.3 Weapon	519.4	1172.6	506.9	95.5	
6.4					
6.5 Ammunition	168.6	926.9	164.6	294.0	
6.6					
6.7 Communications	88.6	76.6	86.5	50.1	
6.8 Fire Control	5074.1	4392.3	4951.6	2872.2	
6.9 Other Recurring	1487.4	XXX	2310.0	1339.9	
6.10 System/Project Mgt.	401.0	664.2	XXX	XXX	
6.11 Other (GFE,ST&E,TRANS, ENGR. CHANGES)	85.1	1098.0	XXX	XXX	
6.12 Integration					
6.13 Recurring Flyaway	18637.1	16053.3	18571.3	10772.2	
6.14					
7. Peculiar Support	182.6	1146.9	XXX	XXX	
8. Initial Spares & Repair Parts	211.1	1495.8	XXX	XXX	
9. TOTAL COSTS	21267.5	21386.7	19587.1	10772.2	

1/ From Format B-1

2/ From Format B-5

*Assumed Quantity

FORMAT B-1

NATO Systems Cost Comparisons

1. System Family Main Battle Tanks 2. NATO Requirement 21000*

		A (FY1979M$)	B (FY1979M$)	C (FY1979M$)	D Total Cost	E
3.	System	XM-1 (105mm gun)	LEOPARD II	CHIEFTAIN	XXX	
4.	Quantity	7058	12942	1000	21000	
5.	R & D	577.2	283.9		861.1	
6.	Non-Recurring Production	924.5	451.1		1375.6	
7.	Recurring Production	7072.6	11445.2	513.0	19030.8	
	7.1 Frame	2918.8	4723.4	211.7	7853.9	
	7.2 Engine	1099.7	1779.5	79.8	2959.0	
	7.3 Weapon	193.0	312.4	14.0	519.4	
	7.4					
	7.5 Ammunition	62.7	101.4	4.5	168.6	
	7.6					
	7.7 Communications	32.9	53.3	2.4	88.6	
	7.8 Fire Control	1885.7	3051.6	136.8	5074.1	
	7.9 Other Recurring	XXX	1423.6	63.8	1487.4	
	7.10 System/Project Mgt	401.0	XXX	XXX	401.0	
	7.11 Other (GFE, ST&E, TRANS, ENGR. CHGS.)	85.1	XXX	XXX	85.1	
	7.12 Integration					
	7.13 Recurring Flyaway (7.1 thru 7.13)	6678.9	11445.2	513.0	18637.1	
	7.14					
8.	Peculiar Support	182.6	XXX	XXX	182.6	
9.	Initial Spares & Repair Parts	211.1	XXX	XXX	211.1	
10.	TOTAL COSTS	8574.3	12180.2	513.0	21267.5	

U.S.Prod.

*Assumed Quantity

FORMAT C-1

NATO Systems Cost Comparisons

1. System XM-1 (105mm gun) 2. U.S. Requirement 7058

	Cost Elements	A Learning Curve	B Units	C Cost (FY1979M$)	D Avg.Unit Cost (FY79$)	E First Unit Cost (FY79$)
3.	R & D	XXX	XXX	577.2	XXX	XXX
4.	Non-Recurring Production	XXX	XXX	924.5	XXX	XXX
5.	Recurring Production (5,6,7)	XXX	7058	7072.6	1002069	XXX
	5.1 Frame	94.3 %	7058	2918.8	413545	612105
	5.2 Engine	91.0 %	7058	1099.7	155809	372867
	5.3 Weapon (105mm)	95.15%	14418	193.0	13386	24495
	5.4					
	5.5 Ammunition (105mm)	91.1 %	315257	62.7	199	903
	5.6					
	5.7 Communications	100 %	7058	32.9	4662	4662
	5.8 Fire Control	100 %	7058	1885.7	267172	267172
	5.9					
	5.10 System/Project Mgt.	XXX	7058	401.0	XXX	XXX
	5.11 Other (GFE,ST&E, TRANS,ENGR.CHGS.)	XXX	7058	85.1	12057	XXX
	5.12 Integration					
	5.13 Recurring Flyaway (Total 5.1 to 5.13)	XXX	7058	6678.9	946288	XXX
	5.14					
6.	Peculiar Support	XXX	7058	182.6	25871	XXX
7.	Initial Spares & Repair Parts	XXX	7058	211.1	29909	XXX
8.	TOTAL COSTS	XXX	XXX	8574.3	XXX	XXX

APPENDIX A-1

EXPLANATION OF XM-1 COSTS (U.S. QUANTITY):

1. Quantity of XM-1 to be produced: 7058.

2. Production rate: 60 per month for approximately 10 years.

3. XM-1 equipped with: 105mm gun.

4. Costs are stated in FY1979 dollars.

5. Cost elements used are directly relateable to those used in the Army cost Analysis Paper (ACAP), 30 May 1976, "A comparative analysis of field and DA staff cost estimate, XM-1 tank system."

6. Costs stated in the baseline cost estimate (BCE), XM-1 Project Manager, May 1978, are not separated by cost element.

7. BCE costs have been verified by Directorate of Cost Analysis, Comptroller of the Army, HQ. D.A.

8. Costs, by cost element, can be derived for the BCE of May 1978.

a. Compute % of tank costs by cost element for tank production recurring costs by using ACAP of 30 May 1976:

Cost Element	FY1976$ (in millions)	Percent of Recurring Costs
Frame	1941.6	41.2694
Engine	731.5	15.5483
Guidance, Control & Commo	21.9	.4655
Fire Control	1254.4	26.6627
Armament	128.4	2.7292
Ammo	41.7	.8863
Other Recurring Costs	585.2	12.4386
TOTAL	4704.7	100.0000%

b. Raise ACAP FY 1976 dollars to FY 1979 dollars using factor of 1.2202 from Budget Review Committee memorandum, 28 Jan. 1978, Comptroller of the Army:

Cost Element	FY1976 $ (In Millions)	Inflation Factor	FY1979 $ (In Millions)
Frame	1941.6	1.2202	2369.1
Engine	731.5	1.2202	892.6
Guidance, Control & Commo.	21.9	1.2202	26.7
Fire Control	1254.4	1.2202	1530.6
Armament	128.4	1.2202	156.7
Ammo	41.7	1.2202	50.9
Other Recurring	585.2	1.2202	714.1
Non-Recurring	587.2	1.2202	716.5
TOTAL	5291.9		$6457.2M

NOTE: PERCENT OF COSTS BY COST ELEMENT REMAINS THE SAME AS IN 8.a.

c. Raise from ACAP quantity of 5784 to BCE quantity of 7058. Spread BCE FY1979 $ by cost element by using % by cost element, derived in para. 8.2. for recurring costs:

Cost Element	Percent	BCE Total Recurring Costs	Cost Element Recurring Costs FY1979 $ (in millions)
Frame	41.2694	7072.6	2918.8
Engine	15.5483	7072.6	1099.7
Guidance, Control & Commo.	.4655	7072.6	32.9
Fire Control	26.6627	7072.6	1885.7
Armament	2.7292	7072.6	193.0
Ammo	.8863	7072.6	62.7
Other Recurring	12.4386	7072.6	879.7
	100.0000		$7072.5 $\overline{M}$

d. Accept BCE non-recurring costs = 924.5

$7997.0 $\overline{M}$

9. Distribution of other recurring production costs was obtained from the BCE of May 1978 and verified by use of CER from ACAP of 30 May 1976. The CER are described in detail in computations of NATO quantity costs and are not described here.

a. System project management (BCE) = = $401.0 $\overline{M}$ (FY79$\overline{M}$$)

b. GFE, system Test & Evaluation, Trans; and Engineering changes (Engine) = $ 85.1 $\overline{M}$ (FY79$\overline{M}$$)

GFE = a. BCE: None specified. Included in other production costs.

b. ACAP CER: $.021867$\overline{M}$ per tank x 7058 tanks x 1.5583 inflation factor = 240.5\overline{M}$ (FY79$)

System Test
and Evaluation = a. BCE; 4.1\bar{M}$ (FY1979$)

b. ACAP CER:

1.0	x 2.04\bar{M}$	x 1.5583
number of tests	per test	inflation factor

= 3.2\bar{M}$ (FY1979$)

Trans. = a. BCE = $81.0M (FY1979$)

b. ACAP CER:

7058	x $7082	x 1.5583
tanks	per tank	inflation factor

= 77.9\bar{M}$ (FY1979$)

Engr. Changes = a. BCE = 0 (tank in production)
(engine)

Total = 0 + 4.1$\bar{M}$ + 81.0$\bar{M}$ = 0 = 85.1\bar{M}$

c. Peculiar support (data, training devices) = 182.6\bar{M}$ (FY79$\bar{M}$$)

Data = a. BCE = 54.9\bar{M}$ (FY1979$\bar{M}$$)

b. ACAP CER =

$2098	x 7058	x 1.5583	= 23.1\bar{M}$ (FY19
per tank	tanks	inflation factor	

Training Devices, Etc. = a. BCE = 127.7\bar{M}$ (FY1979$)

b. ACAP = accepts BCE estimate.

Total = 54.9\bar{M}$ + 127.7$\bar{M}$ = 182.6\bar{M}$ (FY1979$)

d. Initial Spares & Repair Parts = $347.2M̄

BCE = $347.2M̄

ACAP CER:	FRAME:	.11 factor	x $2918.8M̄ prod. cost	= $321.1M̄
	ENGINE:	.08 factor	x $1099.7M̄ prod. cost	=$ 88.0M̄
	COMMO:	.15 factor	x $32.9M̄ prod. cost	= $ 4.9M̄
	FIRE CONTROL:	.15 factor	x $1885.7M̄ prod. cost	= $282.9M̄
			TOTAL	= $696.9M̄

e. Total of other costs (BCE) = $888.2M̄ (FY1979$)

f. BCE costs were used since they represent later figures than the ACAP of May 1976.

10. The total of all costs computed in paragraphs 8 and 9 are $136.1M̄ higher than the BCE costs. This represents an overstatement of spares or production costs. It is a minor difference. Format C-1 lists total BCE costs. Initial spares were reduced by this $136.1M̄ to balance the totals.

11. A copy of an unpublished Independent Parametric Cost Estimate (IPCE), which was developed by Directorate of Army Cost Analysis in order to verify the BCE of May 1978, was obtained for the purpose of examining recurring production costs of the XM-1.

a. The IPCE estimate of recurring production costs for the 105mm XM-1 was $6722.9M̄. This varies from the BCE estimate of $7072.6M̄ by -$349.6M̄ (-4.94%). 4.94% varience is well within the tolerance range expected for a parametric cost estimate and resulted in acceptance of the BCE estimate.

b. However, within the cost elements of recurring production, there were some minor or major variations of the percent of recurring costs incurred by the cost elements when the new IPCE was compared to the 1976 ACAP.

1) Computing range of cost elements percents:

Cost Element	ACAP % of Recurring Costs	IPCE FY 1979 $ (in Millions)	IPCE % of Recurring Costs	Range of Recurring Costs %
Frame	41.2694	2349.3	34.9447	41 to 35
Engine	15.5483	1365.4	20.3097	15 to 20
Guidance, Control & Commo.	.4655	30.1	.4477	.5 to .4
Fire Control	26.6627	1812.9	26.9660	27 to 27
Armament	2.7292	201.5	2.9972	3 to 3
Ammo	.8863	10.6	.1577	.1 to 0
Other Recurring	12.4386	953.1	14.1769	12 to 14
TOTAL	100.0000%	$6722.9M	99.9999%	

2) Percent varience of the ACAP and IPCE cost elements percents:

Cost Element	Range		Varience	Percent of Varience
	ACAP	IPCE		
Frame	41.2694	34.9447	-6.3247	15.3254
Engine	15.5483	20.3097	4.7614	30.6233
Guidance, Control & Commo.	.4655	.4477	- .0178	3.8238
Fire Control	26.6627	26.9660	.3033	1.1375
Armament	2.7292	2.9972	.2680	9.8197
Ammo	.8863	.1577	- .7286	82.2069
Other Recurring	12.4386	14.1769	1.7383	13.9750

3) While the overall varience of IPCE versus BCE was within tolerance (4.94%), within the cost elements of the IPCE and 1976 ACAP there were some significant percentage changes for recurring costs.

4) Since both the ACAP and IPCE are parametric cost estimates and since the objective of parametric estimating is to be "about right", it is felt that cost element percentages of recurring costs which are within the ranges of those shown in para. 9.b. are acceptable.

FORMAT C-1

NATO Systems Cost Comparisons

1. System LEOPARD II 2.Natl. Requirement 12942

Cost Elements	A Learning Curve	B Units	C * Cost (FY1979M$)	D Unit Cost (FY 1979 $)	E 1st unit cost
3. R & D **	XXX	XXX	283.9	XXX	XXX
4. Non-Recurring Production (Tooling, only)	XXX	XXX	451.1	34853	XXX
5. Recurring Production (5, 6, 7)	XXX	12942	11445.2	884345	XXX
5.1 Frame	XXX	12942	4723.4	364964	XXX
5.2 Engine	XXX	12942	1779.5	137501	XXX
5.3					
5.4 Weapon	XXX	12942	312.4	24136	XXX
5.5 Ammunition	XXX	12942	101.4	7837	XXX
5.6					
5.7					
5.8 Fire Control	XXX	12942	3051.6	235790	XXX
5.9 Communications	XXX	12942	53.3	4117	XXX
5.10					
5.11 Other Recurring	XXX	12942	1423.6	110000	XXX
5.12 Integration	XXX				XXX
5.13 Recurring Flyaway	XXX	12942	11445.2	884345	XXX
5.14					
6. AGE/Training/Data					
7. Initial Spares					
8. TOTAL COSTS	XXX	XXX	12180.2	*** 919198	XXX

*Cost of production in [illegible]

**Only R&D for U.S. Production.

***Excludes R&D Unit Cost.

FORMAT B-5

NATO Systems Cost Comparisons

1. System Leopard II 2. NATO Requirement 21000

Cost Elements	A Learning Curve	B Units	C * Cost (FY1979M$)	D Unit Cost	E 1st Unit Cost
3. R & D **	XXX	XXX	283.9	XXX	XXX
4. Non-Recurring Production (Tooling Only)	XXX	XXX	731.9	34853	XXX
5. Recurring Production	XXX	21000	18571.3	884345	XXX
5.1 Frame	XXX	21000	7664.2	364964	XXX
5.2 Engine	XXX	21000	2887.5	137501	XXX
5.3					
5.4 Weapon	XXX	21000	506.9	24136	XXX
5.5 Ammunition	XXX	21000	164.6	7837	XXX
5.6					
5.7 Communications	XXX	21000	86.5	4117	XXX
5.8 Fire Control	XXX	21000	4951.6	235790	XXX
5.9					
5.10					
5.11 Other Recurring	XXX	21000	2310.0	110000	XXX
5.12 Integration					
5.13 Recurring Flyaway	XXX	21000	18571.3	884345	XXX
5.14					
6. Age/Training/Data					
7. Initial Spares					
8. TOTAL COSTS	XXX	XXX	19587.1	*** 919198	XXX

*Cost of Production in U.S.
**Only R&D for U.S. Production.
***Excludes R&D unit cost.

APPENDIX A-6

EXPLANATION OF LEOPARD II COSTS:

1. Quantity of Leopard II to be produced: 12942 for FRG. 21000 for NATO total quantity.

2. Leopard II equipped with: 120mm gun.

3. Costs are stated in FY 1979 dollars.

4. All cost computations are based upon:

a. Unit cost figures from the FMC study:

"Leopard 2 Main Battle Tank", June 1976,

"Cost and Producibility Study" Volume, Interim Report.

These figures are for U.S. Production of the Leopard II.

1) Recurring production unit cost = $724,754 (FY76$)

2) Non-recurring production unit cost (tooling) = $28,563 (FY76$

3) Total unit cost = $753,317 (FY76$)

b. Inflation factor = 1.2202 (FY76 to FY79$)

Source: Budget Review Committee Memorandum, 28 Jan 1978,

Comptroller of the Army, HQ. D.A.

5. Cost elements used are directly relateable to those used in the XM-1 ACAP of 30 May 1976.

6. Unit costs provided in the FMC study of June 1976 are not separated by cost element.

7. Costs, by cost element, can be derived for the FMC study of June 1976 using percent of tank costs from the ACAP of 30 May 1976:

Cost Element	Percent of Recurring Costs	Distributio Recurrin Unit Costs (
Frame	41.2694	$299,102
Engine	15.5483	112,687
Guidance, Control & Commo.	.4655	3,374
Fire Control	26.6627	193,239
Armament	2.7292	19,780
Ammo	.8863	6,423
Other Recurring Costs	12.4386	90,149
TOTAL	100.0000%	$724,754

8. Raise unit cost FY76 $ to FY79 $ using factor of 1.22 from BRC memo of 28 Jan. 1978:

Cost Element	Unit Costs FY 1976 $	x	Factor of 1.2202	=	Unit C FY 197
Frame	$299,102		1.2202		$364,
Engine	112,687		1.2202		137,
Guidance, Control & Co-mo	3,374		1.2202		4,
Fire Control	193,239		1.2202		235,
Armament	19,780		1.2202		24,
Ammo	6,423		1.2202		7,
Other Recurring Costs	90,149		1.2202		110,
Non-Recurring costs	28,563		1.2202		34,
TOTAL	$753,317				$919

9. Compute costs of the FRG quantity of 12942 tanks (21000 NATO - 7058 U.S. production - 1000 U.K. production = 12942.) (NATO quantity of 21000 is assumed. It is also assumed that FRG will produce all except U.S. and U.K. quantities.) and NATO quantity of 21000:

Cost Element	Unit Cost (FY 79 $)	Cost of 12942 FRG Tanks (FY 79 $\overline{M}$ $)	Cost of 21000 NATO Tanks (FY 79 $\overline{M}$ $)
Frame	$364,964	4723.4\overline{M}$	$ 7664.2$\overline{M}$
Engine	137,501	1779.5	2887.5
Guidance, Control & Commo	4,117	53.3	86.5
Fire Control	235,790	3051.6	4951.6
Armament	24,136	312.4	506.9
Ammo	7,837	101.4	164.6
Other Recurring Costs	110,000	1423.6	2310.0
Non-Recurring Costs	34,853	451.1	731.9
TOTAL	$919,198	11896.3\overline{M}$	19303.2\overline{M}$

10. R & D costs from the FMC study of June 1976 were $232,699,000 in FY 1976 $. Raised by the inflation factor of 1.2202 (FY1976$ to FY1979$) this becomes $283,939,310 in FY 1979 $. This represents only R & D for U.S. production of the Leopard II.

11. No allowance has been made for additional engines and main gun tubes since the FMC study did not specifically identify those items or identify their costs. If XM-1 rates for additional engines and main gun tubes are applicable, they can be obtained from the ACAP CER cited in the computations for the XM-1 NATO quantity of 21000 (Format B-5). Corresponding costs can then be computed for the Leopard II.

12. Non-recurring costs cited in the FMC study are for tooling, only. Costs for construction of additional production plants are not known.

13. Age/Training/Data and initial spares are not specifically identified in the unit cost figures shown in the FMC study. It is not known if they are included in the unit costs. These costs have to be obtained.

FORMAT C-1

NATO Systems Cost Comparisons

1. System Chieftain 2. Natl.(U.K.) Requirement 1000

Cost Elements	A Learning Curve	B Units	C * Cost (FY79M$)	D Unit Cost (FY1979$)	E 1st unit cost
3. R & D	XXX	XXX			
4. Non-Recurring Production	XXX	XXX			
5. Recurring Production (5, 6, 7)	XXX	1000	513.0	512,960	XXX
5.1 Frame	XXX	1000	211.7	211,695	XXX
5.2 Engine	XXX	1000	79.8	79,756	XXX
5.3					
5.4 Weapon	XXX	1000	14.0	14,000	XXX
5.5 Ammunition	XXX	XXX	4.5	4,547	XXX
5.6					
5.7					
5.8 Fire Control	XXX	1000	136.8	136,770	XXX
5.9 Communications	XXX	1000	2.4	2,387	XXX
5.10					
5.11 Other Recurring	XXX	1000	63.8	63,805	XXX
5.12 Integration					
5.13 Recurring Flyaway	XXX	1000	513.0	512,960	XXX
5.14					
6. AGE/Training/Data	XXX				
7. Initial Spares	XXX				
8. TOTAL COSTS	XXX	XXX	513.0	512,960	XXX

*At U.K. Inflation Rates.

FORMAT B-5

NATO Systems Cost Comparisons

1. System Chieftain 2. NATO Requirement 21000

Cost Elements	A Learning Curve	B Units	C Cost (FY79M$)	D Unit Cost (FY79$)	E
3. R & D	XXX	XXX			
4. Non-Recurring Production	XXX	XXX			
5. Recurring Production	XXX	21000	10772.2	512,960	
5.1 Frame	XXX	21000	4445.6	211,695	
5.2 Engine	XXX	21000	1674.9	79,756	
5.3					
5.4 Weapon	XXX	21000	95.5	14,000	
5.5 Ammunition	XXX	21000	294.0	4,547	
5.6					
5.7 Communications	XXX	21000	50.1	2,387	
5.8 Fire Control	XXX	21000	2872.2	136,770	
5.9					
5.10					
5.11 Other Recurring	XXX	21000	1339.9	63,805	
5.12 Integration					
5.13 Recurring Flyaway	XXX	21000	10772.2	512,960	
5.14					
6. AGE/Training/Data	XXX				
7. Initial Spares	XXX				
8. TOTAL COSTS	XXX	XXX	10772.2	512,960	

*At U.K. Inflation Rates.

APPENDIX A-5

EXPLANATION OF CHIEFTAIN COSTS:

1. Quantity of Chieftain to be produced: 1,000 for U.K., 21,000 for NATO total quantity..

2. Costs are converted from FY1972 U.K. pounds to FY1979 dollars.

3. All cost computations are based upon:

a. Unit cost figures from The Institute of Cost and Management Accountants (UK). Unit cost = 112,000 £. This figure is for U.K. Production of the Chieftain in FY72 £.

b. Conversion factor of $2.50 per pound used to convert 112,000 FY72 £ to $280,000 FY72 $.

c. Inflation factor = 1.5583 (FY72 to FY79 $).

Source: Budget Review Committee Memorandum 28 January, 1978 Comptroller of the Army, Hq. DA.

d. U.K. inflation is at a different rate than U.S. inflation (see paragraph 10).

e. Both U.S. and U.K. rates were used to show the relative cost impacts of inflation in the two countries.

4. Cost elements used are directly relatable to those used in the XM-1 ACAP of 30 May, 1976.

5. The Chieftain unit cost figure is not separated by cost element.

6. The Chieftain unit cost does not include non-recurring costs.

7. Costs, by cost element, can be derived by applying the percent of tank costs from the ACAP of 30 May 1976:

Cost Element	Percent of Recurring Costs	Distribution of Unit Costs (FY72$)
Frame	41.2694	$115,554
Engine	15.5483	43,535
Guidance, Control & Commo.	.4655	1,303
Fire Control	26.6627	74,656
Armament	2.7292	7,642
Ammo.	.8863	2,482
Other Recurring	12.4386	34,828
TOTAL	100.0000%	$280,000

8. Raise unit cost FY72 $ to FY79 $ using the U.S. factor of 1.5583 from BRC memo of 28 Jan. 1978:

Cost Element	Unit Costs FY1972$	x	Factor of 1.5583	=	Unit Costs FY1979$
Frame	$115,554		1.5583		$180,067
Engine	43,535		1.5583		67,841
Guidance, Control & Commo.	1,303		1.5583		2,030
Fire Control	74,656		1.5583		116,336
Armament	7,642		1.5583		11,909
Ammo	2,482		1.5583		3,868
Other Recurring	34,828		1.5583		54.272
TOTAL	$280,000				$436,323

9. Compute costs of the U.K. quantity of 1000 tanks and assumed quantity of 21000 NATO tanks at the U.S. inflation rate.

Cost Element	Unit Costs FY1979 $	Cost of 1000 UK Tanks (FY79M$)	Cost of 21000 NATO Tanks (FY79M$)
Frame	$180,067	$180.1 $\overline{M}$	$3781.4 $\overline{M}$
Engine	67,841	67.8	1424.7
Guidance, Control & Commo.	2,030	2.0	42.6
Fire Control	116,336	116.3	2443.1
Armament	11,090	11.9	250.1
Ammo.	3,868	3.9	81.2
Other Recurring	54,272	54.3	1139.7
TOTAL	$436,323	$436.3 $\overline{M}$	$9162.8 $\overline{M}$

10. *Using the U.K. inflation rate derived from general U.K.* economic inflation indices (expected to be a more conservative rate than the military procurement inflation rate), unit costs would be inflated from the FY1972 unit cost base as follows:

a. U.K. Economic Year Indices / Average Yearly Raise

Year	Index	Average Yearly Raise	
1970	100	--------------	
75	185.5	17.1	(5 years)
76	223.7	38.2	(1 year)
77	245.9	22.2	(1 year)

b. 1972 = 100 + 2 x 17.1 = 134.2

c. Realign to Base Year 1972

Year	Old Index	New Index
1972	134.2	100
75	185.5	138.2
76	223.7	166.7
77	245.9	183.2

d. Raise unit cost FY1972 $ to FY1979 $ using U.K. factor of 1.832 (index of 183.2):

Cost Element	Unit Costs FY1972 $	x	Factor of 1.832	=	Unit Costs FY 1979 $
Frame	$115,554		1.832		$211,695
Engine	43,535		1.832		79,756
Guidance, Control & Commo.	1,303		1.832		2,387
Fire Control	74,656		1.832		136,770
Armament	7,642		1.832		14,000
Ammo	2,482		1.832		4,547
Other Recurring	34,828		1.832		63,805
TOTAL	$280,000				$512,960

e. Compute costs of the U.K. quantity of 1000 tanks and assumed quantity of 21000 NATO tanks at the U.K. inflation rate.

Cost Element	Unit Cost (FY79 $)	Cost of 1000 U.K. Tanks (FY79 $\bar{M}$ $)	Cost of 21000 NATO tanks (FY79 $\bar{M}$ $)
Frame	$211,695	$211.695 $\bar{M}$	$4445.6 $\bar{M}$
Engine	79,756	79.756	1674.9
Guidance, Control & Commo.	2,387	2.387	50.1
Fire Control	136,770	136.770	2872.2
Armament	14,000	14.000	294.0
Ammo	4,547	4.547	95.5
Other Recurring	63,805	63.805	1339.9
TOTAL	$512,960	$512.960 $\bar{M}$	$10772.2 $\bar{M}$

11. Costs calculated at U.K. inflation rates are used in Formats C-1 and B-5.

12. No allowance has been made for additional engines and main gun tubes since the U.K. rates are not known for the initial production of those items or for the initial spares and repair parts (the distribution of U.K. Chieftain unit costs includes an allowance for initial spares and repair parts based on the ACAP of May 1976 allocation of costs among cost elements).

It is also not known if AGE/Training/Data and initial spares are included in the unit cost figure. It is, therefore, assumed that they are not included, and no entries are made for those items on the formats.

13. R & D and non-recurring production figures are also unknown. They are likewise omitted from the formats.

FORMAT C-1

NATO Systems Cost Comparisons

1. System XM-1 (120mm gun) 2. Natl. Requirement 7058

Cost Elements	A Learning Curve	B Units	C Cost (FY79M$)	D Average Unit Cost (FY79$)	E 1st unit cost (FY79$)
3. R & D	XXX	XXX	748.1	XXX	XXX
4. Non-Recurring Production	XXX	XXX	936.7	XXX	XXX
5. Recurring Production (5, 6, 7)	XXX	7058	7596.0	1,076,226	XXX
5.1 Frame	94.3 %	7058	2918.8	413,545	612,105
5.2 Engine	91.0%	7058	1099.7	115,809	372,867
5.3					
5.4 Weapon (120mm)	95.15%	14418	335.4	23,263	XXX
5.5 Ammunition (120mm)	91.1 %	315257	381.9	1,211	XXX
5.6					
5.7					
5.8 Fire Control	100 %	7058	1885.7	267,172	267,172
5.9 Communications	100 %	7058	32.9	4,662	4,662
5.10 System/Project Mgt	XXX	7058	401.0	XXX	XXX
5.11 GFE, ST&E, TRANS, Engr. Changes	XXX	7058	87.2	12,355	XXX
5.12 Integration*					
5.13 Recurring Flyaway	XXX	7058	7142.6	1,001,986	XXX
5.14					
6. AGE/Training/Data	XXX	7058	233.3	33,055	XXX
7. Initial Spares	XXX	7058	220.1	31,184	XXX
8. TOTAL COSTS	XXX	XXX	9280.8	XXX	XXX

*Included under R & D.

APPENDIX A-3

EXPLANATION OF XM-1 COSTS (U.S. QUANTITY, WITH 120mm GUNS):

1. Quantity of XM-1 to be produced: 7058.

2. Production Rate: 60 per month for approximately 10 years.

3. XM-1 equipped with: 120mm gun.

4. Costs are stated in FY1979 $.

5. Cost elements used are directly relateable to those used in the ACAP of 30 May 1976.

6. Costs stated in the BCE of May 1978 are not separated by cost element.

7. BCE costs have been verified by Directorate of Cost Analysis, Comptroller of the Army, HQ, D.A.

8. Basic costs computed in Appendix A-1 for the 105mm gun version of the XM-1 also apply to the 120mm gun version. Costs are then increased for additional R & D to adapt the 120mm gun to the XM-1, for production of the more expensive 120mm gun and ammo, for modification of the tank frame and components to accept the 120mm gun, and for minor added costs for various other items.

9. Adjustment to XM-1 105mm gun tank costs to reflect the added cost of the 120mm gun equipped XM-1:

Cost Element	XM-1 (105mm) From Format C-1 (FY1979 $\overline{M}$ $)	Added cost from BCE for 4623 XM-1 with 120mm gun (FY1979 $\overline{M}$ $)	Added cost for all 7058 XM-1 with 120mm gun (FY1979 $\overline{M}$ $)	Total Cost for 7058 XM-1 with 120mm gun (FY1979 $\overline{M}$ $)
Frame	2918.8	---	---	2918.8
Engine	1099.7	---	---	1099.7
Guidance, Control & Commo.	32.9	---	---	32.9
Fire Control	1885.7	---	---	1885.7
Armament	193.0	93.3	142.4	335.4
Ammo	62.7	209.1	319.2	381.9
System/Proj. Mgt.	401.0	---	---	401.0
GFE, ST&E, Trans. & Engr. Changes	85.1	1.4	2.1	87.2
Peculiar Support	182.6	33.2	50.7	233.3
Initial Spares & Repair Parts	211.1	5.9	9.0	220.1
TOTAL	7072.6	342.9	523.4	7596.0

10. Computation of added cost for all 7058 XM-1 equipped with the 120mm gun (paragraph 9):

a. To raise to 7058 XM-1 with 120mm gun from BCE quantity of 4623 XM-1 with 120mm gun:

Cost Element	BCE Costs for 4623 XM-1 with 120mm (FY1979 $\overline{M}$ $)	Factor $\frac{7058}{4623} = 1.5267142$	Cost of all 7058 XM-1 with 120mm (FY1979 $\overline{M}$ $)
Armament	$93.3 $\overline{M}$	1.5267142	$142.4 $\overline{M}$
Ammo	209.1	1.5267142	319.2
Trans.	1.4	1.5267142	2.1
Initial Spares	5.9	1.5267142	9.0

b. Compilation of peculiar support costs:

Cost Element	BCE Cost (FY1979\$)
Training	\$13.2 $\overline{M}$
Data	.4
Support Eqpt.	.4
120mm gun Spt.	19.2

\$33.2 $\overline{M}$ x 1.5267142 = \$50.7 $\overline{M}$ (FY79$\overline{M}$\$)
factor

11. Computation of non-recurring production costs (tooling):

a. Added: \$8.0 $\overline{M}$ (FY79\$) x 1.5267142 = \$12.2 $\overline{M}$ (FY1979$\overline{M}$\$)
Added tooling for 4623 XM-1 with 120mm gun; factor

b. Cost for 7058 XM-1 with 105mm = \$924.5$\overline{M}$ (FY79$\overline{M}$\$)

Added for 7058 XM-1 with 120mm = 12.2

\$936.7$\overline{M}$ (FY79$\overline{M}$\$)

12. Computation of R & D costs:

Cost for 7058 XM-1 with 105mm = \$577.2$\overline{M}$ (FY79$\overline{M}$\$)

Added for 7058 XM-1 with 120mm = 170.9

\$748.1$\overline{M}$ (FY79$\overline{M}$\$)

13. Integration costs are included in R & D costs. BCE of May 1978 listed \$77.6$\overline{M}$ (FY1979$\overline{M}$\$) for 120mm gun integration.

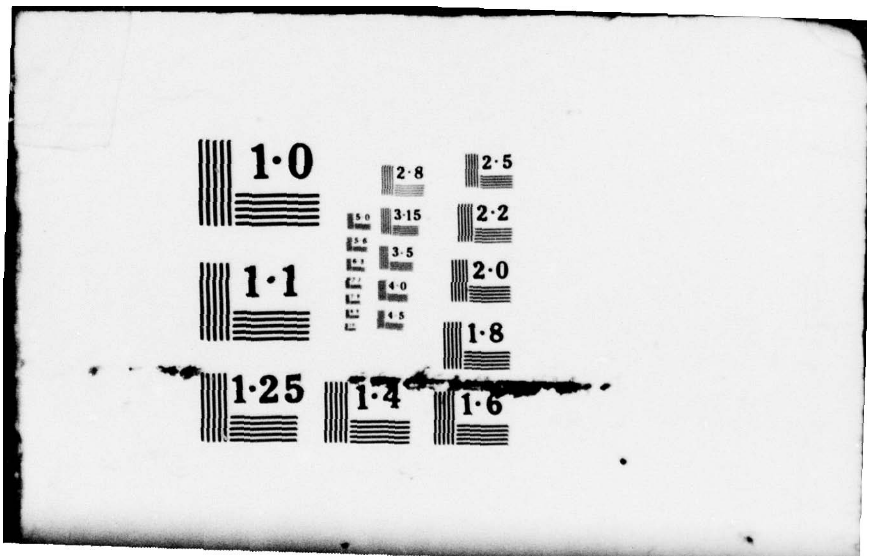
14. R & D costs for 120mm gun/ammo. development is \$93.3$\overline{M}$ (FY1979$\overline{M}$\$).

AD-A072 352 VERTEX CORP ROCKVILLE MD F/G 5/3
METHODOLOGY TO QUANTIFY THE POTENTIAL NET ECONOMIC CONSEQUENCES--ETC(U)
OCT 78 D GREENWOOD, B P KLOTZ, T A SMITH MDA903-78-C-0166

UNCLASSIFIED NL

2 OF 2
AD
A072352

END
DATE
FILMED
9 - 79
DDC



1·0
2·8
2·5
3·15
2·2
3·5
2·0
4·0
1·1
4·5
1·8
1·25
1·4
1·6

FORMAT B-5

NATO Systems Cost Comparisons

1. System XM-1 (120mm Gun) 2. NATO Requirement 21000*

Cost Elements	A Learning Curve	B Units	C Cost (FY1979M$)	D Avg. Unit Cost(FY79$)	E First Unit Cost(FY79$)
3. R & D	XXX	XXX	748.1	XXX	XXX
4. P Non-Recurring Production (Tooling) (2 new plants not incl.)	XXX	XXX	1942.6	XXX	XXX
5. Recurring (5,6,7) Production	XXX	21000	18696.0	890286	XXX
5.1 Frame	94.3%	21000	6315.1	300719	612105
5.2 Engine	91.0%	21000	1407.6	67029	372867
5.3					
5.4 Weapon (120mm)	95.15%	42840	1172.6	27372	XXX
5.5 Ammunition (120mm)	91.1%	938000	926.9	988	XXX
5.6					
5.7 Communications	100 %	21000	76.6	3648	3648
5.8 Fire Control	100 %	21000	4392.3	209158	209158
5.9					
5.10 System/Project Mgt.	XXX	21000	664.2	XXX	XXX
5.11 Other (GFE,ST&E,TRANS, ENGR. CHANGES)	XXX	21000	1098.0	52286	XXX
5.12 Integration					
5.13 Recurring Flyaway (Total 5.1 to 5.13)	XXX	21000	16053.3	764443	XXX
5.14					
6. Peculiar Support	XXX	21000	1146.9	54614	XXX
7. Initial Spares & Repair Parts	XXX	21000	1495.8	71228	XXX
8. TOTAL COSTS	XXX	XXX	21386.7	XXX	XXX

*Assumed Quantity

APPENDIX A-4

EXPLANATION OF XM-1 COSTS (NATO QUANTITY, WITH 120mm GUN):

1. Quantity of XM-1 to be produced = 21000.

2. XM-1 Equipped with: 120mm gun.

3. Costs are stated in FY 1979 $.

4. Cost Elements used are directly relateable to those used in the ACAP of 30 May 1976.

5. Basic costs computed in Appendix A-2 for the 104mm gun version of the XM-1 also apply to the 120mm gun version. Costs are then increased for additional R&D to adapt the 120mm gun to the XM-1, for production of the more expensive 120mm gun and ammo, for modification of the tank frame and components to accept the 120mm gun, and for minor added costs for various other items.

6. Adjustment to XM-1 105mm gun tank costs to reflect the added cost of the 120mm gun equipped XM-1:

Cost Element	XM-1 (105mm) From Format C-1 For NATO Quantity (FY1979M$)	Added Cost From BCE For 10606 XM-1 With 120mm Gun (FY1979M$)	Added Cost For All 21000 XM-1 with 120mm Gun (FY1979M$)	Total Cost For 21000 XM-1 with 120mm Gun (FY1979M$)
Frame	$ 6315.1 M	---	---	$ 6315.1 M
Engine	1407.6	---	---	1407.6
Guidance, Control & Commo	76.6	---	---	76.6
Fire Control	4392.3	---	---	4392.3
Armament	711.7	232.8	460.9	1172.6
Ammo	140.8	397.0	786.1	926.9
System/Proj. Mgt.	664.2	---	---	664.2
GFE, ST&E, TRANS. & Engr. Changes	1021.0	38.9	77.0	1098.0
Peculiar Support	1054.6	46.6	92.3	1146.9
Initial Spares & Repair Parts	1477.6	9.2	18.2	1495.8
TOTAL	$17261.5 M	$724.5 M	$1434.5 M	$18696.0 M

7. Computation of added cost for all 21000 XM-1 equipped with the 120mm gun (paragraph 6):

a. To raise to 21000 XM-1 with 120mm gun from BCE Quantity of 10606 XM-1 with 120mm gun:

Cost Element	BCE Costs For 1606 XM-1 with 120mm gun (FY 1979 $\overline{M}$ $)	Factor $\frac{21000}{10606}$ = 1.9800113	Cost of All 21000 XM-1 with 120mm gun (FY 1979 $\overline{M}$ $)
Armament	$232.8 $\overline{M}$	1.9800113	$460.9 $\overline{M}$
Ammo	397.0	1.9800113	786.1
Trans.	38.9	1.9800113	77.0
Initial Spares	9.2	1.9800113	18.2

b. Compilation of peculiar support costs:

Cost Element	BCE COST (FY1979 $\overline{M}$ $)
Training	$22.5 $\overline{M}$
Data	.4
Support Eqpt.	.4
120mm Gun Spt.	23.3

$46.6 $\overline{M}$ x 1.9800113 = $92.3 $\overline{M}$ (FY1979 $\overline{M}$ $)
factor

8. Computation of non-recurring production costs (tooling):

a. Added: $8.0 $\overline{M}$ (FY79 $\overline{M}$ $) x 1.9800113 = $15.9 $\overline{M}$ (FY1979M$)
Added tooling for 10606 XM-1 with 120mm gun; factor

b. BCE cost for 2 existing plants for tooling (7858 XM-1) = $ 924.5 $\overline{M}$
BCE equivalent of tooling for 2 added plants (14143 XM-1) = 1002.2

(4 Plants) Estimated Total Tooling = $1926.7 $\overline{M}$

c. Total for approximate NATO quantity of 21000:

Tooling for 4 plants = $1926.7 $\overline{M}$

Added for 120mm tooling = 15.9

TOTAL = $1942.6 $\overline{M}$ (FY 1979 $\overline{M}$ $)

9. Non-recurring costs for construction of 2 new plants or for the conversion costs of 2 additional existing plants is not known.

10. Computation of R & D Costs:

Cost of 14143 XM-1 with 105mm gun =	577.2\overline{M}$ (FY79$\overline{M}$$)
Added for 14143 XM-1 with 120mm gun = (No added R & D to reach quantity of 21000)	170.9
	748.1\overline{M}$ (FY79$\overline{M}$$)

11. Integration costs are included in R & D costs. BCE of May 1978 listed 77.6\overline{M}$ (FY1979$\overline{M}$$) for 120mm gun integration.

12. R & D Costs for 120mm gun/ammo development is 93.3\overline{M}$ (FY1979$\overline{M}$$).

FORMAT B-5

NATO Systems Cost Comparisons

1. System XM-1 (105mm Gun) 2. NATO Requirement 21000*

Cost Elements	A Learning Curve	B Units	C Cost (FY1979M$)	D Avg. Unit Cost (FY1979$)	E First Unit Cost (FY1979$)
3. R & D	XXX	XXX	577.2	XXX	XXX
4. Non-Recurring Production (Tooling) (2 new plants not incl.)	XXX	XXX	1926.7	XXX	XXX
5. Recurring Production (5,6,7)	XXX	21000	17261.5	821976	XXX
5.1 Frame	94.3%	21000	6315.1	300719	612105
5.2 Engine	91.0%	21000	1407.6	67029	372867
5.3 Weapon (105mm)	95.15%	42840	711.7	33890	24495
5.4					
5.5 Ammunition (105mm)	91.1%	938000	140.8	150	903
5.6					
5.7 Communications	100 %	21000	76.6	3648	3648
5.8 Fire Control	100 %	21000	4392.3	209158	209158
5.9					
5.10 System/Project Mgt.	XXX	21000	664.2	XXX	XXX
5.11 Other (GFE,ST&E, TRANS, ENGR.CHGS)	XXX	21000	1021.0	48619	XXX
5.12 Integration					
5.13 Recurring Fly Away (Total 5.1 to 5.13)	XXX	21000	14729.3	701395	XXX
5.14					
6. Peculiar Support	XXX	21000	1054.6	50219	XXX
7. Initial Spares & Repair Parts	XXX	21000	1477.6	70362	XXX
8. TOTAL COSTS	XXX	XXX	19765.4	XXX	XXX

*Assumed Quantity

APPENDIX A-2

EXPLANATION OF XM-1 COSTS (NATO QUANTITY):

1. Quantity of XM-1 to be produced: 21000.

2. XM-1 Equipped with 105mm gun.

3. Costs are stated in FY 1979 dollars.

4. BCE costs (BCE of May 1978) are not shown for NATO total quantity (including total U.S. production of the XM-1).

5. Costs, by cost element, can be derived by a straight-line extension of costs from the U.S. XM-1 production quantity of 7058 to the total U.S./NATO quantity of 21000 (an assumed quantity to avoid a classified quantity.) (Approximates three times the U.S. production quantity.)

Cost Element	Quantity=7058 FY1979M$	Factor to * Raise From 7058 to 21000	Quantity=21000 FY1979M$
Frame	2918.8	2.9753471	8684.4
Engine	1099.7	2.975371	3272.0
Guidance, Control & Commo.	32.9	2.975371	97.9
Fire Control	1885.7	2.975371	5610.6
Armament	193.0	2.975371	574.2
Ammo.	62.7	2.975371	186.6
Other Recurring	879.7	2.975371	2617.4
	$7072.5		$21043.1M

$$*\frac{21000}{7058} = 2.9753471$$

6. Costs derived in para. 5., however, do not allow for learning and economies of scale. Therefore, costs must be adjusted to allow for those effects. The difference between the costs in para. 5 and the adjusted costs represents the <u>savings</u> due to learning and economies of scale, (see para. 8). Paragraph 7 gives an estimated total cost at the NATO/U.S. production quantity based upon a predicted composite learning/economies of scale rate of 95% to 100%. The ACAP indicates this range based on a historical/parametric point of view. Individual cost elements/components have learning/economies of scale rates of 91% to 100%. The ACAP provides some parametric estimating techniques to provide cost estimates for the cost elements at the NATO/U.S. production quantity.

a. <u>FRAME</u>.

CER:

$$\text{Total Cost} = \left[\begin{array}{l}\text{First}\\ \text{Unit}\\ \text{Cost}\end{array} \times \frac{\text{Quantity}}{2} \times \left(\frac{\text{Quantity}}{2}\right)^{-.08467}\right]\left[1.0 + \begin{array}{l}\text{Engineering}\\ \text{Factor}\end{array}\right] \times 2 \times \begin{array}{l}\text{Inflation}\\ \text{Factor}\end{array}$$

NOTE: Total production quantity is divided by two, costed, and then multiplied by two to allow for two plant operation.

First Unit Cost (Theoretical) = \$392,803 (FY 1972 \$)

Quantity = 21000.

Engineering % factor = .076

Inflation factor = 1.5583 (FY 72 to FY 79 \$)

Learning curve = 94.3% (Equals: $\frac{\text{Ln}.943}{\text{Ln}.2} = -.08467$)

Computation:

$$\text{Total Cost} = \left[392{,}803 \times \frac{21000}{2} \times \left(\frac{21000}{2}\right)^{-.08467}\right]\left[1.0 + .076\right] \times 2 \times 1.5583$$

$$= \$6315.1\overline{M} \quad (\text{FY}1979\$)$$

b. <u>ENGINE</u>.

1) CER:

$$\text{TOTAL COST} = \left[\begin{matrix}\text{Number}\\ \text{of}\\ \text{Man Years}\\ \text{Engr.}\end{matrix} \times \begin{matrix}\text{Average}\\ \text{Man Year}\\ \text{Cost}\\ \text{Engr.}\end{matrix} + \begin{matrix}\text{First}\\ \text{Unit}\\ \text{Cost}\end{matrix} \times \text{Quantity} \times \text{Quantity}^{-\begin{matrix}\text{Learning}\\ \text{Curve}\\ \text{Slope}\\ \text{Coefficient}\end{matrix}} + \right.$$

$$\left. \begin{matrix}\text{Number}\\ \text{of}\\ \text{Man Years}\\ \text{Q.C.}\end{matrix} \times \begin{matrix}\text{Average}\\ \text{Man Year}\\ \text{Cost}\\ \text{Quality}\\ \text{Control}\end{matrix} + \begin{matrix}\text{Prod.}\\ \text{Cost,}\\ \text{Trans.}\end{matrix}\right] \times \begin{matrix}\text{Inflation}\\ \text{Factor}\end{matrix}$$

First Unit Cost, Production = \$.239,278 (FY72$\overline{M}$\$)

Average Manyear Cost, Engineering = \$.050,082 (FY72$\overline{M}$\$)

Average Manyear cost, Quality Control = \$.050,082 (FY72$\overline{M}$\$)

Number of Manyears, engineering = 20

Number of manyears, quality control = 10

Learning curve = 91% (Equals: Coefficient = $\frac{Ln.910}{Ln.2}$ = -.13606)

Production cost, transmission = \$108.86 (FY 72 $\overline{M}$ \$)

Inflation factor = 1.5583 (FY 72 to FY 79 \$)
NOTE: BRC memo. of 26 Jan. 1978

Quantity = 21000.

NOTE: ACAP omitted the production quantity of engines in the CER, should read: $\begin{matrix}\text{First}\\ \text{Unit}\\ \text{Cost}\end{matrix} \times \text{Quantity} - \begin{matrix}\text{Slope}\\ \text{Coefficient}\end{matrix} \times$

Quanti

2) Computation:

$$\text{Total Costs} = \left[20 \times .050,082 + .239,278 \times 21000 \times 21000^{-.13606} + \right.$$

$$\left. 10 \times .050,082 + 108.86\right] \times 1.5583 =$$

\$1407.6$\overline{M}$ (FY1979\$)

c. COMMUNICATIONS.

1) CER:

$$\text{TOTAL COST} = \text{QUANTITY OF VEHICLES} \times \text{AVERAGE COST PER RADIO} \times \text{INFLATION FACTOR}$$

Quantity of vehicles - 21000.

Average cost per radio - $2341 (FY72$)

Inflation factor - 1.5583 (FY72 to FY79 $)

Learning Curve - 100% (assumed)

2) Computation:

$$\text{TOTAL COST} = 21000 \times 2341 \times 1.5583 = \$76{,}607{,}586 \text{ (FY79 \$)} = \underline{\underline{\$76.6M}} \text{ (FY79 \$)}$$

d. FIRE CONTROL.

1) CER:

Learning Curve Slope Coefficient

$$\text{TOTAL COST} = \text{AVERAGE UNIT COST} \times \text{NUMBER OF TANKS} \times \text{INFLATION FACTOR}$$

Learning Curve - 100% - 1.0 coefficient of slope

Average unit cost - $134,222 (FY72$)

Number of tanks - 21000.

Inflation factor - 1.5583 (FY72 to FY79$)

2) Computation:

$$\text{TOTAL COST} = \$134{,}222 \times 21000^{1.0} \times 1.5583 = \underline{\underline{\$4392.3\overline{M}}} \text{ (FY79\$)}$$

e. ARMAMENT (105mm)

1) CER:

$$\text{TOTAL COST} = \left[\text{First Unit Cost} \times \left(\text{Total Prior Buy} + \text{Quantity of Tubes}\right)^{(\text{Learning Curve Slope Coefficient})} - \text{Total Prior Buy}^{(\text{Learning Curve Slope Coefficient})}\right]$$

$$\left[1.0 + \text{Quality Control \& Proof Acceptance Factor}\right] \times \text{Inflation Factor}$$

First Unit Cost, production = $15,719 (FY72$)

Total Prior Buy = 7,212

Quantity of tubes = 42,840 (Number of tanks x 2.04 factor which provides 104% spare tubes 21,000 x 2.04 = 42,840.)

Learning Curve - 95.15% (equals coefficient = $\frac{\text{Ln}.95}{\text{Ln}.2}$ = -0.0717)

Quality Control & Proof Acceptance Factor = .07

Inflation Factor = 1.5583 (FY72 to FY79 $)

2) Computation:

$$\text{TOTAL COST} = \left[15{,}719 \times \left(7{,}212 + 42{,}840^{(1.0-0.0717)} - 7{,}212\right)^{(1.0-0.0717)}\right]$$

$$\left[1.0 + .07\right] \times 1.5583 =$$

$711.7M̄ (FY79$)

f. <u>AMMUNITION (105mm)</u>.

1) CER:

$$\text{TOTAL COST} = \left[\begin{matrix}\text{Theoretical}\\ \text{First Unit}\\ \text{Cost}\end{matrix} \times \begin{matrix}\text{Number}\\ \text{of}\\ \text{Rounds}\end{matrix}^{\begin{matrix}\text{Learning}\\ \text{Curve}\\ \text{Coefficient}\end{matrix}} \times \begin{matrix}\text{Number}\\ \text{of}\\ \text{Rounds}\end{matrix}\right] \times \left[1.0 + \begin{matrix}\text{Quality Control}\\ \text{\& Engineering}\\ \text{Support Factor}\end{matrix}\right] \times \text{Inflation Factor}$$

Theoretical first unit cost - \$579.44 (FY72 \$)

Number of rounds = 134 rounds per tank x 21000 tanks x 1/3 (1/3 of all rounds are new) = 938000

Learning curve - 91.1% (equals: coefficient = $\frac{\text{Ln}.91}{\text{Ln } 2}$ = -.13606)

Q.C. & Engr. Support factor - .08

Inflation factor - 1.5583 (FY72 to FY79 \$)

2) Computation:

$$\text{TOTAL COST} = \left[579.44 \times 938000^{-.13606} \times 938000\right] \times \left[1.0 + .08\right] \times 1.5583$$

$$= \$140{,}812{,}920 = \$140.8\overline{M} \text{ (FY79\$)}$$

g. <u>OTHER, RECURRING PRODUCTION</u>.

Consists of:

1) Government furnished equipment (GFE):

a) drivers night vision device
b) commander's weapon (40 cal.)
c) loader's weapon
d) co-axial weapon (7.62 mg)
e) OEM
f) CBR
g) main gun mount

CER:

TOTAL COST = Thruput (BCE Estimate - 1976) x Inflation Factor

Thruput - $.021,867$\overline{M}$ (FY72M$) x 21000 quantity - 459.2\overline{M}$

Inflation Factor - 1.5583 (FY72 to FY79 $)

Computation = .021867$\overline{M}$ x 21000 x 1.5583

= 715.6\overline{M}$ (FY79 $)

2) System Test and Evaluation:

CER:

TOTAL COST = QUANTITY OF TEST PERIODS x AVERAGE COST PER PERIOD x INFLATION FACTOR

Quantity of test periods = 1.0

Average cost per period = 2.04$\overline{M}$ (FY72 $)

Inflation factor = 1.5583 (FY72 to FY79 $)

Computation:

TOTAL COST = 1.0 x 2.04\overline{M}$ x 1.5583 = 3.2\overline{M}$

3) Data:

CER: Total Cost = thruput x inflation factor

Thruput = 12.134\overline{M}$ (FY72 $) = $2098 per vehicle

Inflation factor = 1.5583 (FY72 to FY79 $)

Quantity of vehicles = 21000.

Computation:

TOTAL COST = $2098 x 21000 x 1.5583 = 68.7\overline{M}$ (FY79 $)

4) System/Project Management:

a) CER:

$$\text{TOTAL COST} = \begin{array}{c}\text{QUANTITY}\\ \text{OF}\\ \text{MAN YEARS}\end{array} \times \begin{array}{c}\text{AVERAGE}\\ \text{COST PER}\\ \text{MAN YEAR}\end{array} \times \begin{array}{c}\text{INFLATION}\\ \text{FACTOR}\end{array}$$

Computation:

TOTAL COST = 1040 x $50,000 x 1.5583

= $81.0 $\overline{M}$ (FY 79 $)

b) BCE of May 1978 lists project management costs as 534.2\overline{M}$ for 14143 tanks and 401.0\overline{M}$ for 7058 tanks.
Added cost for double quantity of tanks is 133.2\overline{M}$ to produce another increment of 6857 tanks should also add about $130.0M.
Estimated total project mgt. costs ($401.0M + 133.2$\overline{M}$ + 130.0$\overline{M}$).
= $664.2M (FY1979M$). Accept this in lieu of CER estimate.

5) Training devices and components:

CER:

TOTAL COST = Thruput x Inflation Factor

Thruput - 149\overline{M}$ (FY72 $) x 4.245948 Operational factor = 6327\overline{M}$

Inflation factor = 1.5583 (FY72 to FY79 $)

Computation:

TOTAL COST = $632.7M x 1.5583 = $985.9M (FY79$)

6) Transportation of tanks and initial spares & repair parts:

CER:

$$\text{TOTAL COST} = \begin{array}{c}\text{QUANTITY}\\ \text{OF TANKS}\end{array} \times \begin{array}{c}\text{AVERAGE}\\ \text{TRANS. COST}\\ \text{PER TANK}\end{array} \times \begin{array}{c}\text{INFLATION}\\ \text{FACTOR}\end{array}$$

Computation:

TOTAL COST = 21000 x $7082 x 1.5583

= 231.8\overline{M}$ (FY79 $)

h. ENGINE ENGINEERING CHANGES.

CER:

TOTAL COST = COST FACTOR, ENGR. CHANGES x PRODUCTION COST, ENGINE (RECURRING) x INFLATION FACTOR

Cost Factor, Engr. Changes = .05

Production Cost, Engine (Recurring) = 903.3$\overline{M}$ (FY72 $)

Inflation Factor = 1.5583 (FY72 to FY79)

Computation:

TOTAL COST = .05 x 903.3$\overline{M}$ x 1.5583

= 70.4\overline{M}$ (FY79 $)

i. INITIAL SPARES & REPAIR PARTS.

Consists of :

1) FRAME:

CER:

TOTAL COST = COST FACTOR, PERCENT OF PRODUCTION COST (RECURRING) x PRODUCTION COST (RECURRING) x INFLATION FACTOR

Cost factor, % of prod. cost (recurring) = .11

Production cost (recurring) = 6315.1\overline{M}$ (FY1979 $)

Inflation factor = 1.0

Computation:

TOTAL COST = .11 x 6315.1 x 1.0

= 694.7\overline{M}$ (FY1979$\overline{M}$ $)

2) ENGINE:

CER:

$$\text{TOTAL COST} = \begin{array}{c}\text{COST FACTOR,}\\ \text{PERCENT OF}\\ \text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \begin{array}{c}\text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \text{INFLATION FACTOR}$$

Cost factor, % of prod. cost (recurring) = .08

Production cost (recurring) = $\$1407.6\overline{M}$ (FY79 \$)

Inflation factor = 1.0

Computation:

TOTAL COST = .08 x 1407.6 x 1.0

= $\$112.6\overline{M}$ (FY1979$\overline{M}$ \$)

3) COMMUNICATIONS:

CER:

$$\text{TOTAL COST} = \begin{array}{c}\text{COST FACTOR,}\\ \text{PERCENT OF}\\ \text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \begin{array}{c}\text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \text{INFLATION FACTOR}$$

Cost factor, % of prod. cost (recurring) = .15

Production cost (recurring) = $\$76.6\overline{M}$ (FY 1979 \$)

Inflation factor = 1.0

Computation:

TOTAL COST = .15 x $\$76.6\overline{M}$ x 1.0

= $\$11.5\overline{M}$ (FY1979$\overline{M}$\$)

4) FIRE CONTROL:

CER:

$$\text{TOTAL COST} = \begin{array}{l}\text{COST FACTOR,}\\ \text{PERCENT OF}\\ \text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \begin{array}{l}\text{PRODUCTION}\\ \text{COST}\\ \text{(RECURRING)}\end{array} \times \text{INFLATION FACTOR}$$

Cost factor, % of Prod. Cost (recurring) = .15

Production cost (recurring) = 4392.3\overline{M}$ (FY1979 $)

Inflation factor = 1.0

Computation:

TOTAL COST = .15 x 4392.3\overline{M}$ x 1.0

= 658.8\overline{M}$ (FY1979$\overline{M}$$)

5) TOTAL SPARES = 694.7\overline{M}$ + 112.6$\overline{M}$ + 11.5$\overline{M}$ + 658.8$\overline{M}$ = 1477.6\overline{M}$

j. PECULIAR SUPPORT.

DATA + TRAINING DEVICES & COMPONENTS = 68.7\overline{M}$ + 985.9$\overline{M}$ = 1054.6\overline{M}$(FY
(para.6.1.3) (para.6.1.5)

7. Non-recurring production cost for NATO quantity of 21000.

a. NATO quantity of 21000 requires 2 additional production plants.

BCE: U.S. Prod. of 7058 = $ 924.5$\overline{M}$ (2 existing plants)
" " " 14143 = 1002.2$\overline{M}$ (equivalent of tooling for 2 plants.)

Estimated total tooling = 1926.7\overline{M}$ (FY79$)

b. Construction costs of 2 new plants or conversion costs of 2 additional existing plants is not known.

APPENDIX B

LONG RANGE AIR DEFENSE MISSILES

This appendix presents the methodology for development of costs for long range air defense missile systems. Due to the lack of a suitable competitor for the Patriot long range air defense missile system, a scenario has been created in which a hypothetical competitor has been developed and illustrated. This hypothetical missile system has the following characteristics:

1. It is a European competitor.

2. The quantity of missiles required is the same as for the Patriot: 5,000. This assumes a European requirement equal to that of the U.S.

3. It has an R & D cost which is 15% higher than Patriot R & D costs. This would be expected, due to a more restricted technological base for advanced air defense missiles in western Europe.

4. It has a non-recurring investment cost for tooling and minor plant modification which is 20% higher than the Patriot. In this case, a balance was struck between an older but more adequate plant capacity in the U.S. and a newer but less adequate plant capacity in Europe. The principal difference would lie in present tooling, where the U.S. has a distinct advantage and where European tooling costs would therefore be at least 20% higher.

5. It has a recurring investment cost equal to that of the Patriot. As in the case of non-recurring investment costs, the U.S. advantage of a more adequate but older plant is offset by a newer but less adequate European plant facility. The other factors of tooling efficiency, labor costs, and material costs basically balance out. Therefore, it is assumed that the costs of the missiles and their launch/support/ fire control systems are approximately equal.

In this scenario, the hypothetical competitor to the Patriot is equal to the Patriot in recurring production costs but is slightly higher in R & D and non-recurring production costs. Comparison of the two missile systems is not significant. The methodological development is most significant in illustrating cost savings due to an increase in the production quantity from a U.S. requirement of 5,000 missiles to a total assumed NATO production quantity of 10,000 missiles and due to a reduction in R & D and non-recurring production costs when only one country develops and produces the missile system.

Data sources used in this appendix are:

1. For the Patriot: "Army Cost Analysis Paper Number 4, Independent Parametric Cost Estimate of the SAM-D System," DCA-R-24, November, 1975, Systems Estimates Division, Directorate of Cost Analysis, Comptroller of the Army, Hq. DA.

2. Learning curves: "Army Life Cycle Cost Model for Missile Systems," DCA-R-25, September, 1976, System Estimates Division, Directorate of Cost Analysis, Comptroller of the Army, Hq. DA.

3. Other missile systems: "The World's Missile Systems," November, 1976, 3rd Edition, General Dynamics.

Information in the missile area is generally more difficult to obtain due to the security classification of missile physical and performance characteristics, quantities to be produced and deployed, and costs of both the complete missiles and their components. Because of this situation, missile quantities and costs which were available for the Patriot from Hq, Department of the Army, have been approximated in order to avoid classifying the study. Patriot physical and performance characteristics have also been omitted in order to avoid classification of the study.

A complete spectrum of costs was available for the Patriot. Costs were approximated for an assumed quantity of 5,000 missiles, 150 ammunition units, 620 launchers, and 140 fire control units.

A search was made of available data sources in order to obtain a suitable competitor for the Patriot. General Dynamics' "The World's Missile Systems" was reviewed. It contained only three missile systems which could even be considered as possible competitors for the Patriot: the Bloodhound (UK), the Thunderbird (UK), and the Hawk (U.S.). The data available in "The World's Missile Systems" for the three missile systems is limited in physical and performance characteristics; has no indication of the costs of the R & D, non-recurring investment, and launch/support/fire control systems; and has only a single unit cost estimate for the missile itself. The listed physical and performance

characteristics are insufficient to develop cost estimates using the CER available in the "Army Life Cycle Cost Model for Missile Systems." Finally, it was decided that none of the three missiles was really a technological competitor for the Patriot.

Further search of relevant publications and subsequent discussion with personnel in Hq DA, ISA(OSD), and PA & E(OSD) indicated that no logical competitor exists in the free world for the Patriot. Consequently, the hypothetical competitor for the Patriot was developed.

Costs for the various Formats were then developed. Formats C-1 were prepared for both the Patriot and its hypothetical competitor. The Formats C-1 data were then entered on the Format B-1. A Format B-5 was prepared for the Patriot for the NATO assumed quantity of 10,000 missiles. Finally, the Format A-1 was prepared with the indication of cost savings which might be possible by increasing the U.S. approximate procurement quantity of 5,000 to the assumed NATO quantity of 10,000.

Using the approximated costs provided by System Estimates Division, Hq DA, Patriot costs for the Format C-1 were developed as shown on the following page.

Cost Element	Cost (FY 1975 $\overline{M}\$$)	Cost* (FY 1979 $\overline{M}\$$)	Unit Cost** (FY 1979 $\$$)	Percent of Recurring Cost
Frame	135.0	175.4	35,080	5.86798
Propulsion	146.0	189.7	37,940	6.34639
Warhead	81.0	105.3	21,060	3.52279
Guidance & Control	630.0	818.6	163,372	27.38616
Communications	.3	.4	2,667	.01338
Launcher	280.0	363.8	586,774	12.17088
Fire Control	620.0	805.6	5,754,286	26.95125
Project Management	165.0	214.4	—	7.17272
Other Recurring	89.0	115.7	—	3.87073
Common Support Eqpmt.	71.0	92.3	—	3.08788
Peculiar Spt. Eqpmt.	25.0	32.5	—	1.08728
Initial Spares	58.0	75.4	—	2.52249
TOTALS	$\$2,300.0\ \overline{M}$	$\$2,989.1\ \overline{M}$		99.99993

* Costs were inflated from FY 1975 to FY 1979 dollars using the factor of 1.2994 from "FY 1979 Current/Constant Dollar Conversion Indices", 26 January, 1978, Budget Review Committee, Comptroller of the Army, Hq. DA.

** Unit costs were calculated based on the following assumed quantities of components/cost elements:

Cost Element	Quantity
Frame	5,000
Propulsion	5,000
Guidance & Control	5,000
Communications	150
Launcher	620
Fire Control	140

The costs of R & D and non-recurring investment for the hypothetical missile were calculated as follows:

Cost Element	Patriot Cost	Factor*	Hypothetical Missile Cost
R & D	$ 1,819.2 M̄	1.15	$ 2,092.1 M̄
Non-recurring Production	181.9 M̄	1.20	218.3 M̄

* 15% more for R & D
  20% more for non-recurring production

Hypothetical missile costs for recurring production are the same as for the Patriot.

Patriot costs for the assumed NATO quantity of 10,000 missiles were computed as follows:

Cost Element	Cost (FY 1979 M̄$)	Comment
R & D	$1,819.2	No change in R & D for increased production.
Non-recurring Production	$ 209.2	Experience in other areas, such as main battle tanks, indicates that there is only a minor increase in non-recurring production cost, primarily for additional tooling, when there is existing plant capacity available. A doubling in the production quantity would be expected to increase costs for tooling by approximately 15%.

$ 181.9 M̄ x 1.15 = $209.2 M̄

Cost Element	Cost (FY 1979 $\bar{M}$\$)	Comment
Frame	\$ 350.8	Frame, warhead, communications, other recurring production, common support equipment, and peculiar support equipment do not have learning. Consequently, a doubling in quantity from 5,000 to 10,000 would double the cost of 5,000 missiles.
Warhead	210.6	
Communications	.8	
Other Recurring Production	231.4	
Common Support Equipment	184.6	
Peculiar Support Equipment	65.0	
Project Management	\$ 285.2	Experience in other weapon systems, such as main battle tanks, indicates an increase of approximately 33% in project management costs when the production quantity is doubled. $\$214.4\ \bar{M} \times 1.33 = \$285.2\ \bar{M}$
Propulsion	\$ 300.0	The Army Life Cycle Cost Model for Missile Systems contains CERs which can be used to calculate the costs for the NATO quantity of 10,000 missiles for propulsion, guidance & control, launcher, and fire control. However, the CERs are dependent upon the use of either physical or performance characteristics of the missile system. To avoid security classification of the study, none of the calculations are shown for computation of costs of these cost elements and the calculated costs are only representations of the calculated costs- not the actual calculated costs themselves.
Guidance & Control	1,190.0	
Launcher	530.0	
Fire Control	1,200.0	
Initial Spares	\$ 110.0	Initial spares and repair parts costs are based upon a calculated percentage of recurring investment costs. These costs have also been approximated.

These Patriot costs for an assumed NATO quantity of 10,000 missiles indicate the scale of potential savings due to one country developing and producing the long range air defense missile systems for all NATO members. It must be emphasized that they should not be considered as exact cost estimates or as precise savings. They only indicate the scale of potential savings.

During the study of long range air defense missiles, several significant findings became apparent:

1. U.S. missile data can be obtained on both a classified and an unclassified basis. Physical and performance characteristics of later missile systems are largely classified. Certain cost data are sensitive, since they, along with production quantities, could be used to deduce some idea of classified matters.

2. Data concerning the missile systems of other countries are either very limited or nonexistent. A major data gathering effort is required in order to fill in this information gap.

3. A cost comparison methodology can be developed and illustrated even when major data gaps exist.

4. A full test of the methodology is not possible until significant data gaps are filled.

5. When comparisons are made of the relative costs of all types of weapon systems, not just long range air defense missiles, several factors must be considered and assumptions made as to their impact:

a. The inflation rates in the countries concerned.

b. Technological bases.

c. Production plant capacity and age.

d. Reliability of published data.

e. Availability of security classified data.

f. State-of-the-art in cost estimating techniques. Particularly the availability of parametric cost estimating techniques when the current technology thresholds are breached in weapon system development.

g. Interpretation of cost data provided by civilian contractors and the Military Services. This includes: distribution of costs among R & D, non-recurring production, and recurring production cost elements; allocation of costs among the components of weapon systems; omission/understatement/misstatement of sunk costs and government furnished equipment (GFE); assumptions concerning learning curves, the impact of production rates, and the time period of weapon system production.

6. The costs of weapon system integration are not visible. Only minor integration costs are shown in published data. They are largely hidden within other costs. Isolating integration costs may not be possible due to the cost of the effort to identify them. Interpretation of what the term "integration" means is also a problem. Integration must be clearly defined for both the producer of the information and for the user before any major

data gathering effort is undertaken to identify integration costs. Since the methodology of this study is dependent to some degree upon integration costs, this is a major area for further research.

In summary, maximum utilization of the methodology contained in this study is possible when:

1. More cost data is obtained concerning the weapon systems of other countries.

2. The impact of inflation rates in other countries is better understood.

3. Integration costs for weapon systems are obtained.

4. Certain other data gaps, previously mentioned, are filled.

In order to utilize the methodology, precise cost figures are not essential. However, "order of magnitude" figures are required for cost comparisons. A data bank on European costs in the weapon acquisition process, developed on an industry/country basis, would appear to be a necessity if policy makers intend to compare European and U.S. systems prior to actual production.

FORMAT A

NATO Systems Cost Comparisons

1. System Family Long Range Air Defense Missiles   2. **NATO Requirement** 10,000*

	A[1]	B[2]	C	D	E.
3. System	NATO	Patriot			Cost Savings B vs. A
4. Quantity	10,000	10,000			
5. R & D	3,911.3	1,819.3			2,092.0
6. Non-Recurring Production	400.2	209.2			191.0
7. Recurring Production Cost Element	5,978.2	4,658.4			1,319.8
7.1 Frame	350.8	350.8			-
7.2 Propulsion	379.4	300.0			79.4
7.3 Warhead	210.6	210.6			-
7.4 Guidance & Control	1,637.2	1,190.0			447.2
7.5 Launcher	727.6	530.0			197.6
7.6 Project Management	428.8	285.2			143.6
7.7 Communications	.8	.8			-
7.8 Fire Control	1,611.2	1,200.0			411.2
7.9 Other Recurring	231.4	231.4			-
7.10 Common Spt. Eqpmt.	184.6	184.6			-
7.11 Other (Specify)					
7.12 Integration					
7.13 Recurring Flyaway (7.1 through 7.12)	5,762.4	4,483.4			1,279.0
7.14					
8. **Peculiar Support Equipment**	65.0	65.0			-
9. **Initial Spares**	150.8	110.0			40.8
10. **TOTAL COSTS**	10,289.7	6,686.8			3,602.9

* Assumed Quantity   [1] From Format B-1   [2] From Format B-5

FORMAT C-1

NATO Systems Cost Comparisons

1. System Patriot　　　2. Nat L Requirement 5,000*

Cost Elements	A Learning Curve	B Units	C Cost $M (FY 1979$)	D Unit Cost (FY 1979$)
3. R & D			1,819.2	
4. Non-Recurring Production			181.9	
5. Recurring Production Cost Elements		5,000	2,989.1	597,820
5.1 Frame		5,000	175.4	35,080
5.2 Propulsion	92%	5,000	189.7	37,940
5.3 Warhead		5,000	105.3	21,060
5.4 Guidance & Control	85%	5,000	818.6	163,372
5.5 Launcher	85%	620	363.8	586,774
5.6 Project Management			214.4	
5.7 Communications		150	.4	2,667
5.8 Fire Control	Radar=88% Data =90% Processor	140	805.6	5,754,226
5.9 Other Recurring			115.7	
5.10 Common Spt. Eqpmt.			92.3	
5.11 Other (Specify)				
5.12 Integration				
5.13 Recurring Flyaway (5.1 through 5.12)		5,000	2,881.2	576,240
6. Peculiar Support Equipment			32.5	
7. Initial Spares			75.4	
8. TOTAL COSTS			4,990.2	

* Assumed Quantity

FORMAT C-1

NATO Systems Cost Comparisons

1. System Hypothetical 2. Nat l Requirement 5,000*

Cost Elements	A Learning Curve	B Units	C Cost M (FY 1979$)	D Unit Cost (FY 1979$)
3. R & D			2,092.1	
4. Non-Recurring Production			218.3	
5. Recurring Production Cost Elements		5,000	2,989.1	597,820
5.1 Frame		5,000	175.4	35,080
5.2 Propulsion	92%	5,000	189.7	37,940
5.3 Warhead		5,000	105.3	21,060
5.4 Guidance & Control	85%	5,000	818.6	163,372
5.5 Launcher	85%	620	363.8	586,774
5.6 Project Management			214.4	
5.7 Communications		150	.4	2,667
5.8 Fire Control	Radar= 88% Data= 90% Processor	140	805.6	5,754,286
5.9 Other Recurring			115.7	
5.10 Common Spt. Eqpmt.			92.3	
5.11 Other (Specify)				
5.12 Integration				
5.13 Recurring Flyaway (5.1 through 5.12)		5,000	2,881.2	576,240
6. Peculiar Support Equipment			32.5	
7. Initial Spares			75.4	
8. TOTAL COSTS			5,299.5	

* Assumed European NATO Requirement

FORMAT B-5

NATO Systems Cost Comparisons

1. System Patriot 2. NATO Requirement 10,000*

Cost Elements	A Learning Curve	B Units	C Total Cost FY 1979M$	D
3. R & D			1,819.2	
4. Non-Recurring Production			209.2	
5. Recurring Production Cost Elements		10,000	4,658.4	
5.1 Frame		10,000	350.8	
5.2 Propulsion	92%	10,000	300.0	
5.3 Warhead		10,000	210.6	
5.4 Guidance & Control	85%	10,000	1,190.0	
5.5 Launcher	85%	1,240	530.0	
5.6 Project Management			285.2	
5.7 Communications		300	.8	
5.8 Fire Control	Radar = 88% Data = 90% Processor	280	1,200.0	
5.9 Other Recurring			231.4	
5.10 Common Spt. Eqpmt.			184.6	
5.11 Other (Specify)				
5.12 Integration				
5.13 Recurring Flyaway (5.1 through 5.12)		10,000	4,483.4	
6. Peculiar Support Equipment			65.0	
7. Initial Spares			110.0	
8. TOTAL COSTS			6,686.8	

* Assumed Quantity

FORMAT B-1

NATO Systems Cost Comparisons

1. System Family Long Range Air Defense Missiles   2. NATO Requirement 10,000*

	A	B	C Total Cost FY 1979 $s	D	E
3. System	Patriot	Hypothetical	[redacted]		
4. Quantity	5,000	5,000	[redacted]		
5. R & D	1,819.2	2,092.1	3,911.3		
6. Non-Recurring Production	181.9	218.3	400.2		
7. Recurring Production Cost Element	2,989.1	2,989.1	5,978.2		
7.1 Frame	175.4	175.4	350.8		
7.2 Propulsion	189.7	189.7	379.4		
7.3 Warhead	105.3	105.3	210.6		
7.4 Guidance & Control	818.6	818.6	1,637.2		
7.5 Launcher	363.8	363.8	727.6		
7.6 Project Management	214.4	214.4	428.8		
7.7 Communications	.4	.4	.8		
7.8 Fire Control	805.6	805.6	1,611.2		
7.9 Other Recurring	115.7	115.7	231.4		
7.10 Common Spt. Eqpmt.	92.3	92.3	184.6		
7.11 Other (Specify)	[redacted]	[redacted]	[redacted]		
7.12 Integration	[redacted]	[redacted]	[redacted]		
7.13 Recurring Flyaway (7.1 through 7.12)	2,881.2	2,881.2	5,762.4		
7.14	[redacted]	[redacted]	[redacted]		
8. Peculiar Support Equipment	32.5	32.5	65.0		
9. Initial Spares	75.4	75.4	150.8		
10. TOTAL COSTS	4,990.2	5,2995	10,289.7		

* Assumed Quantity

APPENDIX C

This Appendix develops a comparative cost analysis for NATO tactical air. In effect, the scenario is a replay of a decision recorded in the June, 1975 Memorandum of Understanding between the United States and several European nations for a coproduction program on the F-16. There are significant differences, however, between the alternative procurement strategies considered in the screening methodology as utilized here and the very specific arrangements that evolved in the F-16 buy. Using generalized terminology, the methodology addresses procurement strategy and the F-16 buy procurement tactics.

The Tactical Air Scenario considered here examines the comparative costs of a NATO buy of 1,388 aircraft. The United States requirement is 650 and the Participating European Governments have a requirement for 738 aircraft. Two aircraft are in contention, the U.S. F-16 and the European Mirage F.1M53.

A Format B-1 was initiated indicating a NATO requirement of 1,388 aircraft to be provided by a U.S. procurement of 650 F-16's and a European procurement of 738 Mirage F.1's. A Format B-5 was initiated showing a NATO requirement of 1,388 to be filled by an F-16 buy.

Format C-1's were completed for each aircraft. In both instances, costs were available in 1975 currency. The F-16 cost data were obtained in FY1975 dollars from a USAF Independent Cost Analysis dated December, 1976. The Mirage cost data were available only at aggregate levels, and the procedure used to complete the Format C-1 for the Mirage is described in the next three paragraphs.

The Dessault Mirage F.1-E aircraft, using the SNECMA M53 turbofan engine was a principal competitor to the F-16. At the time of the competition, Dassault had orders for 300 planes and was approaching a production rate of seven aircraft per month. Thus the projected NATO buy would start with unit 301. Another plane considered was the Swedish Viggen, but this is not played in the scenario. Its unit costs exceed those of the F.1M53.

Cost data were located in the May, 1975 issue of International Defense Business, page 295. 102 Mirage aircraft were cited as costing 2,390 million in Netherlands currency (Program costs). The Format C-1 was filled in by translating the Netherlands currency to 1975 dollars by an exchange rate of 2.43:1 and using an 85% learning curve to determine lot (301-1038) and unit program costs. Using F-16 percentage breakouts for subsystem and other cost categories, the Mirage cost elements were estimated and entered on Format C-1. These percentages are:

Non-Recurring Production	1.9% of Program [1]
Frame	31.6
Engine	21.5
Armament	3.5
Avionics	13.4
System Project Management	.97
Engineering Change Orders	5.2
Peculiar Support Equipment	16.0
Initial Spares	6.0
Integration and Assembly	6.6 [2]

[1] Non-Recurring Production does not vary by production quantity. It is 2% of F-16 Program costs at a production of 650 aircraft.

[2] Integration and Assembly for the F-16 was determined at Unit 1 labor costs and projected on an 81% learning slope.

INTERIM FORMAT A

NATO SYSTEMS COST COMPARISON
(FY1979 millions of dollars)

1. System Family: Tactical Air

2. NATO Requirement: 1,388 Aircraft

Millions of 1979 $

	F-16/ Mirage From B-1	F-16 From B-5	NATO SAVINGS
3. System	F-16/ Mirage From B-1	F-16 From B-5	NATO SAVINGS
4. Program Costs	13,383	9,239	4,144

A second Mirage cost estimate was obtained from an April, 1975 issue of Aviation Week. This reported a sale of 25 Mirage F.1 aircraft to Morocco for $320 million. Assuming a 25% spare parts buy as part of the sale, this gives an average unit cost of $9.6 million for units 301-325. This compares reasonably with the $8.5 million estimate for units 301-1,038 (all in 1975 dollars).

The FY1975 dollar estimates for both aircraft were converted to FY1975 dollars using a factor of 1.2994. This factor was obtained from a Comptroller of the Army document dated 26 January, 1978, subject: FY1979 current/constant dollar Conversion Indices. The FY1979 dollar values were used in completing Format B-1. Format B-1 takes the C-1 data for both systems and provides a total cost to NATO when both systems are procured.

Since Mirage unit costs are greater than F-16 unit costs on the C-1's (when the Mirage quantity of 738 exceeds the F-16 quantity of 650), the decision was made to complete a Format B-5 on the F-16 buy only. The F-16 B-5 Format is in FY1975 dollars and uses the USAF source document. This reflects costs based on a modified coproduction procurement since the F-16 is not being produced on a U.S.-only procurement. The B-5 costs were converted to FY1979 dollars using the same conversion factor (1.2994) as before, and entered on Interim Format A. B-1 costs were also entered on Interim Format A, providing a cost comparison.

FORMAT B-1

NATO Systems Cost Comparisons
(Millions of FY 1979 dollars)[1]

1. System Family Tactical Air   2. NATO Requirement 1,388

	A	B	C	C	E Total Cost
3. System	F-16	F.1M53			
4. Quantity	650	738			
5. R & D	$902				902
6. Non-Recurring Production	105	155			260
7. Recurring Production Cost Element	[redacted]				
7.1 Frame	1,659	2,573			4,232
7.2 Engine	1,126	1,750			2,876
7.3 Armament	186	285			471
7.4 Weapon					
7.5 Ammunition					
7.6 Ammunition					
7.7 Avionics	702	1,092			1,794
7.8 Fire Control					
7.9 Electrical System					
7.10 System Project Management	53	79			132
7.11 Engineering Change Orders	259	424			683
7.12 Integration[2]	343	414			757
7.13 Recurring Flyaway	3,984	6,202			10,186
7.14					
8. Peculiar Support Equipment	837	1,303			2,140
9. Initial Spares	316	489			805
10. TOTAL COSTS	5,241	8,142			13,383

1. FY 1975 dollars updated by factor of 1.2994
2. Part of Frame (7.1 above)

FORMAT B-5

NATO Systems Cost Comparisons

(Millions of FY 1975 dollars)

1. System F-16 2. NATO Requirement 1,388

Unique Coproduction

Cost Elements	A Learning Curve	B Units	C Cost (millions)	D Unit Cost (millions)
3. R & D			694.3	
4. Non-Recurring Production			80.5	.06
5. Recurring Production Cost Elements				
5.1 Frame			2,291.0	1.65
5.2 Engine		1188-2576	1,719.0	1.24
5.3 Armament			255.2	.18
5.4 Weapon				
5.5 Ammunition				
5.6 Ammunition				
5.7 Avionics			953.8	.69
5.8 Fire Control				
5.9 Electrical System				
5.10 System/Project Management			67.7	.05
5.11 Engineering Change Orders			254.4	.18
5.12 Integration[1]			441.0	
5.13 Flyaway			5,619.1	4.05
5.14				
6. AGE/Training/Data	9% of 5.13-4		1,044.2	.75
7. Initial Spares			446.7	.32
8. TOTAL COSTS			7,110.5	5.12

[1] Part of Frame (5.1 above)

FORMAT C-1

NATO Systems Cost Comparisons
(Millions of FY 1975 dollars)

1. System F-16 2. Natl. Requirement 650

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost	E 1st unit cost
3. R & D			694.3		
4. Non-Recurring Production			80.5	.12	
5. Recurring Production Cost Elements					
5.1 Frame			1,276.8	1.96	
5.2 Engine			866.6	1.33	
5.3 Armament			142.8	.22	
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Avionics			540.2	.83	
5.8 Fire Control					
5.9 Electrical System					
5.10 System/Project Management	100%		40.6	.06	
5.11 Engineering Change Orders			199.3	.32	
5.12 Integration	81%				
5.13 Recurring Flyaway			3,066.3	4.72	$12.312
5.14					
6. AGE/Training/Data			643.8	.99	
7. Initial Spares			243.1	.37	
8. TOTAL COSTS			4,033.7	6.20	

Source: USAF Independent Cost Analysis, December, 1976

FORMAT C-1

NATO Systems Cost Comparisons
(Millions of FY 1975 dollars)

1. System Mirage F.1/M53 2. Natl. Requirement 738

Cost Elements	A Learning Curve	B Units	C Cost	D Unit Cost	E 1st unit cost
3. R & D					
4. Non-Recurring Production			119	.16	
5. Recurring Production Cost Elements					
5.1 Frame			1,980	2.68	
5.2 Engine			1,347	1.82	
5.3 Armament			219	.30	
5.4 Weapon					
5.5 Ammunition					
5.6 Ammunition					
5.7 Avionics			840	1.15	
5.8 Fire Control					
5.9 Electrical System					
5.10 System Project Management			61	.08	
5.11 Engineering Change Orders			326	.44	
5.12 Integration[1]			413	.56	
5.13 Recurring Flyaway	85%		4,773	6.46	$38.46M
5.14					
6. AGE/Training/Data			1,003	1.36	
7. Initial Spares			376	.51	
8. TOTAL COSTS			6,266	8.49	

[1] Part of Frame (5.1 above)

Analysis

Two options were available to the United States and the Participating European Governments in early 1975. The first option (Format B-1) was a production strategy of two aircraft, one a U.S.-developed plane and the other a European-developed plane. The NATO requirement was for 738 aircraft and the U.S. requirement was 650. If this strategy were selected, the cost to NATO over the production buy would be $13,383 billion (FY1975 $).

The second production strategy was a unique coproduction effort where European firms would subcontract to the U.S. prime contractors. The generalized ground rules provided for European firms to realize, in aggregate, a percentage of the production effort acceptable to their governments. The resultant products might be assembled either in the U.S. or in Europe, and the total buy of the five concerned nations would be 1,388 aircraft (i.e.; 738 plus 650 or the recognized requirement). The USAF estimate translated into FY1979 dollars is shown as $9,239 billion. This is a NATO savings of over $4 billion.

Program costs were used in this analysis. Full scale development costs for the F-16 are estimated at $900 million. This cost is incurred under both options and is not used in the comparative analysis for two reasons:

- It does not affect the delta cost of $4 billion.

- We have no information on the development costs for the Mirage. Since 300 Mirage units were programmed at the time of the decision, some Mirage development costs should be treated as charges against French, Greek, and Kuwaiti requirements. However, this figure is also unavailable.

There is literally no way in which the selected option could prove to be economically inferior to the rejected (Format B-1) option. A massive increase in F-16 production costs would affect both options adversely, and we would, in effect, have a version of Zeno's paradox.

APPENDIX D

DATA BANK REQUIREMENTS

Long term and/or frequent use of this methodology for measuring potential cost savings through NATO weapon system standardization and/or procurement specialization can be enhanced through development and maintenance of a data bank. This data bank should include information in the following categories:

- Cost/Quantity Relationships
- Integration and Assembly Factors
- Technological Transfer Factors
- Statistical Cost Estimating Relationships
- Non-Recurring Production Factors.

This information can be obtained from the Military Services and/or other Department of Defense sources. We recommend that the collection process be formalized so that the Service and other DoD source responses are as precise as possible.

Cost/Quantity Relationships

There are three types of industry cost/quanity relationships that are applicable to the methodology. The preferred relationship is an industry learning or experience curve reflecting costs. The other two can be used in tandem as a substitute for a cost curve but require additional information. These are learning curves (labor) and price curves (material).

A cost curve (or composite learning curve) reflects probable cost changes as the quantity of an item produced either increases or decreases from available projections. The labor learning curve reflects the labor hours for the same process and the price curve reflects material price change.

The data bank should accumulate cost learning curves, labor learning curves, and price curves by industry in the United States and in NATO countries. These curves should reflect cost/quantity relationships for major subsystems (WBS Level 3). The data bank should be structured to ensure that each curve is adequately labeled as to nature (cost, labor, or price), industry, and country.

Integration and Assembly Factors

The monitoring of parallel progress of component production and the mating of these components into a working system is one of the miracles of modern weapon system technology. As weapon systems become more complex, the integration and assembly process also increases in complexity. The cost of this effort is generally measured in the labor hours of the engineers and factory laborers who monitor, redesign, and assemble. For accounting purposes, this labor effort is usually included in the frame or hull subsystem; however, it can be separately identified as a level 4 element in the work breakdown structure.

A collection effort should be undertaken to identify integration and assembly effort on recent weapon system production and to develop factors by major system so that this cost element can be treated as a subsystem in the methodology. This effort should include attention to NATO member nation experience. Until such data is forthcoming, the methodology can use a figure of 60% of frame labor at first production unit and an 81% learning curve. This factor is based on an examination of F-16 costs prepared by the Aeronautics Systems Division, USAF.

Technical Transfer Factors

There is a cost involved when one manufacturer begins to produce a product designed by another. The second manufacturer must acquire the necessary plans and his engineers and other key personnel must become acquainted with the demands of the new production process on their organization and facilities. These costs are somewhat analogous to research and development. They may be described as the costs of technological transfer.

There is probably a relationship between the complexity of a system and the cost of technological transfer. This cost factor is likely to vary from industry to industry. The costs probably increase when the tranfer involves manufacturers in more than one country. Fortunately, there is experience outside the Department of Defense in this area. When a U.S. firm licenses a NATO member nation to produce a U.S.-developed product, the European firm incurs the cost of technological transfer. In view of the large number of licensing agreements in existence, it is presumed that

manufacturers have developed planning factors that relate this cost to some element of production costs. These planning factors, by industry and cross-country implications, should become part of the NATO cost methodology data bank.

More specifically, the data requirement is :

> What is the cost, as a percentage of total production cost (or other major cost category such as R & D), likely to be incurred when a second manufacturer is proposed for a system? This information should be by industry and by specific country sets, such as FRG to U.S., U.S. to U.K., etc.

Statistical Cost Estimating Relationships (CERs)

The data bank should accumulate general CERs for military system subsystems. These have been developed by Commodity and System Commands in the Military Services. These are generally either performance or physical characteristic oriented. It should be emphasized that the type of CERs required for this methodology is generalized at the subsystem. Such CERs are used primarily by the Services during the Advanced Development and Full Scale Development phases of weapon system development. They are used in this methodology primarily as a fall-back position when a Service estimate is unavailable.

Non-Recurring Production Factors

The data bank should accumulate factors for predicting probable

non-recurring production costs at the system level in the U.S. and NATO member nations. These factors could be of a CER nature or be based on other data available to the military Services.